E. M. R. Willis Ap. 25. 98.

COMMON THINGS

AND

ELEMENTARY SCIENCE

IN THE

FORM OF OBJECT LESSONS.

BY

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THE OBJECT LESSON LIBRARY

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PREFACE.

THE object of the author in publishing this volume is to supply teachers with a manual of matter and method on Common Things and the Elements of Science, thus providing materials for courses of lessons on "Elementary Science" as a class subject. Three points have been kept in view in preparing the lessons; first, the production of full and accurate information; second, the arrangement of the matter in its teaching order; and third, the indication of the method by which the ideas are to be worked out. In many cases the particular experiments to be performed, the questions to be put, and the diagrams to be used are given.

It has, of course, been necessary to make a selection of subjects in each section of the book, preference, therefore, has been given to those which are likely to come under a child's notice in his daily life, the study of which will help to cultivate careful observation and intelligent inquiry; habits which will tend to make the individual exact in his statements, correct in his judgments, and useful in his future avocations. The subjects chosen embrace all those mentioned in the Code. All the lessons have been worked out from original sources; those on manufactures and minerals, from notes made while visiting factories and mines. The statistics have been taken from the latest official returns.

In Part III. an attempt is made to show how the elements of Science may be taught; not, as is often the case, by mere definitions and generalizations, but by means of lessons in which the children gain ideas for themselves by the exercise of their senses. Much of the matter in this section is the reproduction of lessons given by the author in the course of his official duties as assistant training master.

It has been deemed unnecessary to mention the Standards to which the lessons are to be given, as that will, in a great measure, depend upon circumstances, such as the previous instruction and the mental capacity of the children. As a general rule the simpler parts of the subjects embraced in Parts I. and II. may be given to infants and children in the lower Standards of the juvenile school; while the more difficult portions and most of the lessons in Part III. may be reserved for the upper Standards. As a matter of fact the lessons on the specific qualities of bodies have several

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times been given to children in Standards II. and III., and with success. Teachers must of course exercise their judgment, both in the choice of subjects for a particular Standard, and in the amount of matter to be included in any one lesson. To economize space, the summaries of the lessons are not given: in actual teaching they should be made as the lesson proceeds, and written on the slate at the dictation of the children. What is thus written, should, at the close of the lesson, be repeated by the class, and, in the case of elder children, form the groundwork of a "home lesson" either in the shape of a "report" or of a "composition lesson."

J. H.

NOTE TO TWELFTH EDITION.

The work has been thoroughly revised for the twelfth edition, and a number of improvements that have been suggested by those using the book have been carried out.

J. H.

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THE

ELEMENTS OF SCIENCE IN THE FORM OF OBJECT LESSONS.

PART I.—COMMON THINGS.

SECTION I.—COMMON OBJECTS.

LESSON 1.—A TABLE.

The objects required for this lesson are, the school table, and a model or pictures of different kinds of tables.

I. General Use of a Table.—Question the children on what is done after the Bible Lesson has been given. Where the teacher places the registers while she is marking them. On the table. By further questions bring out that, writing-books, slates, inkstand, pens, pencils, needlework, flowers, and many other things are placed on a table for convenience sake. At home, books, flowers, and ornaments are placed on a table. At meals we sit down at a table.

II. Parts of a Table.—Direct the children's attention to the table placed in front of the class, and work out the following points:

The school table is made of wood. The wood has been stained and varnished.

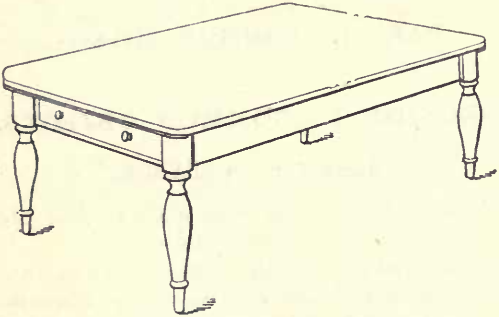
The part on which the books, &c., are placed is called the *top:* this is thick, flat, and smooth. It has four sides, two of which are longer than the other two. Such a shape is called an oblong. The four corners of the top are rounded.

The top stands on, and is fastened to a *frame:* this has four sides and four corners. In the frame there is a drawer, which is the same shape as the top. The frame with the top is lifted up from the ground by *four legs:* these are round; but thinner at the bottom than at the top. The legs are fastened to the frame.

The height of the table above the floor is such that, when a person sits before it, he can do what he has to do with comfort, and when he stands before it he can do his work without having to stoop much.

III. Different Kinds of Tables.—Question the children on what they may have observed respecting the tables in their homes, those in the kitchen, keeping-room and bed-room, aid their memories with pictures, and so work out the following facts:—

The tables used at home are not all like the one used in school. Those used in the kitchen are larger and stronger, and are not painted or varnished. They are kept white by scrubbing. Some of the tables used in the sitting-rooms are round, and have only one thick leg, or pillar, sometimes called the stem—placed under the middle of the top. At the lower end of this pillar are four large broad feet which extend outward nearly as far as the rim of the top; these feet are ornamented, and are often spoken of as "claws."



The top of these tables can be turned upwards by an hinge, and can be removed altogether by taking out the screws.

These large round tables are called *Loo Tables;* they are made of very beautiful wood—walnut, rose-wood, mahogany, &c.; all parts are polished.

When sitting at such a table children should be careful not to scratch the top, nor scrape the feet or pillar with their shoes.

Some large tables called *Dining Tables* are the same shape as the school table; they have the frame so constructed that it can be drawn out and pushed in again, so as to make the table larger or smaller according to the number of people who wish to sit down at the table. These extending tables, as they are sometimes called, have the top made in several pieces called leaves: these can be put on or taken off the frame as may be needed.

Some tables are small, long, and narrow, and made of very fine wood highly ornamented. They are placed at the sides of the rooms, or before a sofa, and are used to stand books, flowers, and ornaments on. Such tables as these are called *Sofa Tables* or *Occasional Tables.* Sometimes these tables are made circular and are supported by a single pillar or stem.

Those tables which are used in bed-rooms to stand a looking-glass on are called *Dressing Tables:* these are sometimes covered with a white cloth, and the frame and legs are covered with white muslin.

Show children pictures of the more uncommon kinds of tables, as Pier, Consol, Card, Work, and Library Tables.

Tell the children that the men who make tables are called Cabinet-makers, a large number of whom live in that part of London called Shoreditch. Those persons who sell tables are called Furniture Dealers or Upholsterers.

LESSON 2.—A CHAIR.

The objects required are, a cane-bottomed chair, and a model or pictures of different kinds of chairs.

I. Use of a Chair.—Question the children on how they feel after they have taken a long walk, or have been standing for any length of time? When they are thus tired what are they glad to do? On what do they like to sit? A chair. The lesson will be on that article of furniture.

II. Parts of a Chair.—Place a chair on the school table in front of the class, direct the children's attention to the parts and their form, and thus work out the following points:—The part of the chair on which we sit is called the *seat:* it is flat and narrower at the back than at the front; it is made of thin strips of cane platted together.

The cane work which forms the seat is held together by the *frame;* this is made of four pieces of wood fastened together.

The part against which a person leans his back when sitting is called the *back;* it consists of a broad flat piece forming the top of the back, and several rounded pieces called bars; these are fastened into holes made in the under side of the top piece of the back and in the upper side of the back piece of the frame of the seat.

The seat is raised above the ground by *four legs;* the two front ones are round, and all four are fastened into holes made in the four corners of the under side of the frame. To keep the legs firm they are fastened together by round pieces of wood called *bars* or *rails.*

III. Different Kinds of Chairs.—Question the children on what they may have observed respecting the chairs which are used at home, or which they may have seen when visiting, or elsewhere. Assist them to express themselves properly, and by using illustrations add to their knowledge. Take the kinds in connection with the apartments in which they are placed, and thus work out the following:—

1. *Kitchen Chairs.*—These have wooden seats: the whole chair is strong, is made of common wood, and is stained and varnished.

2. *Parlour Chairs.*—These are made of fancy wood—mahogany—are French polished, have the seats stuffed with horse-hair, and covered with leather or haircloth. The frames are strong and the legs are not held together by cross rails. The two front legs are round and carved. The backs are curved and slope backward so as to afford an easy position to the body.

3. *Easy or Arm Chairs.*—These are generally rather large chairs with short legs. They are made of mahogany or other fancy wood and are French polished. The back, seat, and rests for the arms are stuffed with horse-hair or flock, and covered either with leather or haircloth. Some *arm* chairs have the back upright; the *easy* chairs have the back curved and slope backwards. Occasionally the seats contain spiral steel springs as well as hair; when this is the case the seat is very elastic.

4. *Drawing-room Chairs.*—These are in some respects like parlour chairs; they are, however, lighter and more ornamental, both in the make of the chair and in the covering of the seat or other stuffed parts; chintz, rich silks, flowered satins, and velvet, &c., being used for this purpose. Some drawing-room chairs have the woodwork beautifully japanned, or painted and gilt. Mixed with the more massy drawing-room chairs it is the custom to have others of a much simpler kind and very light, usually termed *conversation* or *gossiping chairs.* These have the woodwork ornamental, and the seats of split cane or rush, worked in a fancy manner.

5. *Bed-room Chairs.*—These chairs are most usually made light and of common wood, generally beech, stained and varnished: the seats are made of cane. Most of these chairs are made in Buckinghamshire. Some bed-room chairs are made of deal and the seats are composed of rush: sometimes both the wood and the rush are painted. Such chairs are the most common kind made and are called *rush-bottomed chairs.*

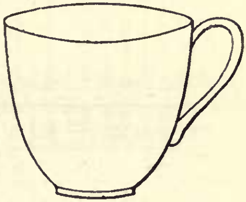
6. Some chairs are made for the *use of children* only. These are of two kinds: those with short legs, so that the child can sit on the seat without having to climb, and those with long legs, so that a little child may sit at the table and reach his food without standing or kneeling on the seat.

Lesson 3.—A CHINA TEA CUP AND SAUCER.

I. The Parts and Qualities:

1. The Cup.—Children to observe the tea cup and saucer, and, aided by the teacher's questions, work out the following matter:

The part of the cup into which the tea is poured is called the *bowl.* At the top of the bowl is the *upper rim,* and at the bottom the *lower rim,* on which the cup stands. When any person wishes to drink from the cup he raises it to his mouth by the *handle.* The handle is fastened to the outside of the bowl.



The whole cup is white, smooth, hard, brittle, and glazed. The bowl is vaulted, thin, translucent, and ornamented.

The rims are circular; the upper one is gilt. The handle is curved, circular, and ornamented.

2. The Saucer.—When in use the cup is placed in a saucer. The part on which the cup stands is called the *bottom;* that into which the tea is poured, the *bowl.* The saucer, like the cup, has *two rims;* the upper one is painted and gilt. The bowl is shallower than that of the cup, but its circumference is greater.

The whole saucer, like the cup, is thin, white, translucent, brittle, and glazed. It matches the cup in the colour and pattern of its ornaments.

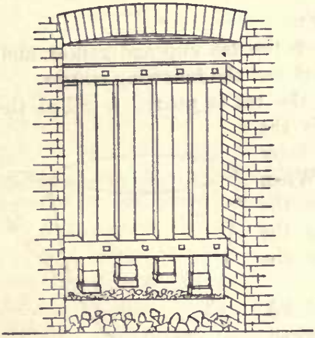
A saucer is a very convenient article; it is much easier to hand a person a cup full of hot tea while standing in the saucer than by the handle of the cup.

II. The Care of the Cup and Saucer.—By referring to the quality of brittleness children will see the necessity for care in handling cups and saucers. If allowed to fall on the floor or table they will break, and if the handle of the cup be struck it may break off. Tea cups without handles do not look well, and they are very inconvenient to use.

After using cups and saucers they should be carefully washed in warm water, then wiped with a clean white cloth, and put away in the cupboard.

III. The Manufacture of a Cup:

1. THE MATERIALS, AND HOW PREPARED FOR USE.—Show these, Cornish clay, flint, and bone-ash. By observing these in their unprepared state, and comparing them with the finished article, the children will see that they must have undergone some change in order to fit them for use; and by considering the nature of each material, they may suggest the probable process. During the whole of this part of the lesson compare the raw material and the partially formed article with the finished one, and so work out the following processes:—

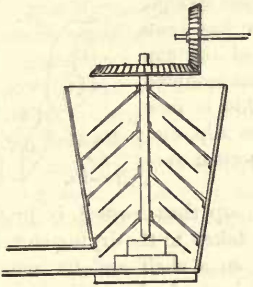

Section of Stamping Machine for Pounding Calcined Flints.

a. The Preparation of Raw Material.—Cornish clay, sometimes called *Kaolin*, which is produced by the decomposition of the felspar of the granite. This washed and formed into a paste. Illustrate. *Flints*—which are obtained from the upper chalk—made red hot (calcined) for thirty hours: when cooled they are white and very brittle. They are now crushed in a stamping machine, and then ground to very fine powder and washed. *Bone-ash*, bones having been boiled to abstract the fat, are burnt in open fires (see lesson on BONES), then ground to a fine powder.

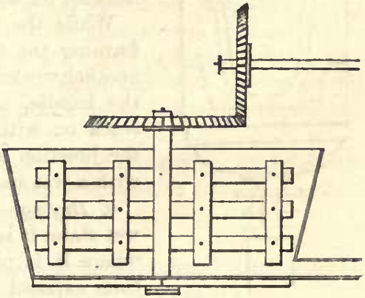
b. The Mixing.—The ingredients being thus prepared, they are mixed together. Proper quantities chosen: ground flints, 66 parts; calcined bones, 100 parts; china clay, 96 parts; Cornish granite, 80 parts. These are united by being stirred up together in vessel containing water. The mixture is afterwards strained through sieves of varying fineness. It now resembles a milky paste, and is called *slip*.

c. Boiling the Slip.—From the fact that the material is in a liquid state, children will see that it could not be moulded into a cup, and they may suggest a method of getting rid of the superfluous water—namely, by boiling. Tell how done. Placed in *slip-kiln*. While boiling stirred to keep the ingredients well mixed. By degrees the water is evaporated, and the mass thickens.

d. Slapping to get rid of the Air.—When of the required consistency, the mass is cut into wedge-shape pieces, and the workman taking a lump of paste, about 60 or 70 lbs., dashes it down on a bench, divides it repeatedly by drawing through it a wire. On each division he takes up one portion of the clay and dashes it down on the other portions, always taking care to slap the layers parallel to each other.



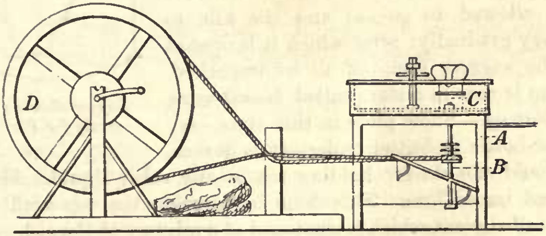
Section of Pug Mill for preparing Clay.



Section of Mixing Machine.

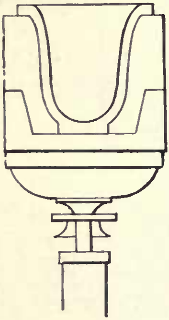
2. Making the Cup:

a. Throwing.—A mass of dough being received from the slapper is cut up into portions with a brass wire. Each portion is weighed. It is then taken to the throwing-machine or *potter's lathe.* This consists of a fixed table A, through which passes an axle B, and having on its upper end a disc C, which revolves with it. The axle is put into motion by turning the fly-wheel D, and this causes a rapid revolution of the disc C, upon which is placed the soft mass of clay to be moulded. When the lump of clay is revolving, the potter with his hands, or with proper tools, fashions it into the required shape.



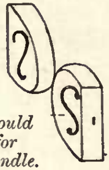
Potter's Wheel or Lathe.

Sometimes the exterior of the cup is formed in a mould, which is put on the revolving disc of the lathe, and the interior of the cup is formed by the hand of the potter. It is finished off with a wet sponge.



Enlarged view of C with Cup being formed, when Mould is used.

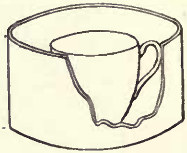
While the potter has been forming the bowl of the cup another workman has moulded the handle, and this is now stuck on with some slip, and the junction is smoothed over with a wet sponge.



Mould for Handle.

b. Drying.—The cup thus formed is in a wet state; it is now taken to the drying stove, where it is placed on a shelf and for some time exposed to a heat of about 85° Fahr. When quite dry it is carefully packed in a coarse earthenware vessel called a "*sagger.*" Several cups are put into a sagger, and they are kept from touching each other by pieces of burnt clay formed for the purpose.

c. Firing.—When the saggers are full they are taken to the kiln and piled up with great care; each pile of saggers is called a "*bung.*" The arrangement being completed, the furnaces are lighted and the whole contents of the kiln subjected to great heat for the space of forty hours. At the end of this time the fire is allowed to go out and the kiln to cool very gradually; after which it is opened and the saggers removed to be unpacked. The cup is now in a state called *biscuit-ware.*



Sagger showing Cup ready for Firing.

d. Glazing.—Show piece in this state—say a water-bottle or butter cooler—it is porous, and would not do for holding tea or any other liquid. Must be rendered impervious. This done by covering the cup with a substance called *glaze*, which is composed of a mixture of Cornish granite, white-lead, and broken glass. These ingredients are ground and mixed in the same way as the slip.

When prepared the cup is dipped into the glaze and again fired for about 14 hours, and then gradually cooled. When the cup leaves the kiln it is covered with a thin coating of transparent glass, and is now quite impervious to water.

e. Ornamenting.—The experience of the children will have taught them that the colours used for ornamenting china will not wash off. Tell why this is so. The colours employed are all really coloured glasses, which have been melted on the glaze. With the material for making the glass is mixed the colouring matter, which is in every case an oxide of a metal. The coloured glass having been made it is ground into a fine powder, mixed with nitre or borax to serve as a flux, and laid on the cup with a hair pencil, and fired. When several colours are used care is taken to put on those last which require the least heat to fuse.

When all the colours have been set the gilding is the next and last thing done. The gold having been prepared, is painted on, then fired, and afterwards burnished.

The SAUCER is formed by pressing and .throwing. Otherwise all the operations in its manufacture are the same as in the cup.

The chief seats of the manufacture of porcelain in this country are in that part of Staffordshire called the Potteries; at Derby; at Coalport, near Colebrook Dale in Shropshire; in the city of Worcester; and at Swinton, near Rotherham in Yorkshire. The most celebrated factories of the present day are those of Messrs. Wedgwood at Etruria in Staffordshire, and the Messrs. Minton and Messrs. Copeland at Stoke-upon-Trent.

LESSONS 4 AND 5.—A TABLE KNIFE AND FORK.

Objects required, a large table knife and fork with bone or ivory handles, and either specimens or pictures of several kinds of knives.

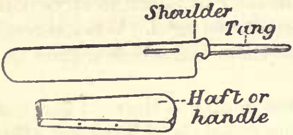
First—THE KNIFE.

I. Introduction. Tell the subject of the lesson. Children to name the different kinds of knives seen and the use to which put. Guide the children's observation of the specimen, and so work out the following matter. Write substance on the slate in the order indicated below.

II. The Parts of a Knife.—When the knife is being used it is held by the *handle*, or *haft* as it is called, which has two ends and four sides. The part used for cutting is called the *blade*, which has two sides, a back, and an edge. At one end of the blade is the rounded point, and at the other the bolster or shoulder. On one of the sides there is a groove in which the maker's name is stamped.

The blade is not fastened to the handle but to a part called the *tang,* which fits into the handle and is fastened to it by *rivets.*

III. Qualities of a Knife.—The handle or "haft" is made of bone (or ivory), the shank-bone of an ox. It is white, smooth, hard, tough, and polished. (See lesson on BONE.)



The blade is made of steel. It is bright, smooth, and hard. The back of the blade is blunt, the edge is sharp.

The shoulder is curved and rounded at the edges. The tang is cylindrical—or flat as the case may be—thin, rough, and tough. The shoulder and tang are made of iron.

The rivets are also made of iron; they are round, short, and flattened at each end.

IV. Different Kinds of Knives. — Some table knives are large and are used for cutting up joints of meat—these are called *Carving Knives.* Such knives as those just examined are called *Dinner* or *Table Knives:* some of these are smaller than others. The smaller sizes are used for cutting pudding or pie, and also for cutting cheese.

Some knives have silver blades, and are used for cutting fish, fruit, and butter when a small piece is wanted at meals.

The man who makes knives is called *a cutler;* the same name is applied to the man who sells them.

V. The Manufacture of a Knife.—If possible procure the raw materials, and by comparing these with the finished article lead children to see the necessity for the various operations, and so work out the following particulars:

1. THE BLADE:

a. Forged from a bar of steel.—Bar made red-hot, placed on an anvil and beaten with hammer. When of proper shape cut off.

b. The shoulder and tang.—The blade fastened to a rod of iron about half an inch square, both made white hot, and beaten with a hammer until both firmly united—this called *welding.* Wrought iron and steel have this property. (See lesson on WROUGHT IRON.)

c. Blade properly shaped.—The blade is now made red-hot, and properly finished on the anvil. The maker's name is then stamped on it.

d. Hardened.—Wrought iron and steel, after being made red-hot, is easily bent, said to be "*soft:*" in this state would not be fit for cutting, so is hardened by being made red-hot, and suddenly plunged into water. This renders the steel brittle, said to be "*hard.*" It is nearly white. If the edge was now made it would be liable to break, so made a little softer again, or

e. Tempered.—The hardened blade is now gradually heated until the colour changes from white to light yellow: it is then suddenly cooled by being plunged into water. The steel is now hard enough to resist being bent easily, and yet tough enough to keep its edge. It is said to be tempered.

f. Ground.—The blade is now fixed in a wooden case, and each side in turn pressed against a revolving grindstone which is kept wet. By this process the blade is made smooth, and the edge partly formed.

g. Finished.—This is a threefold operation, and consists of, first, pressing the blade against a soft wooden wheel on which emery powder is placed. This is called *lapping.* Second, pressing the blade against a *hard* wooden wheel, using fine emery powder. This process is called *glazing.* Third, pressing the blade against a wheel covered with leather. This is called *polishing.*

2. THE HANDLE:

a. Cut out of bone or ivory, as the case may be. Properly shaped and polished.

b. Hole drilled through the centre, either all through or partly, according to quality of knife. When the tang is long enough to pass through the whole length of handle knife said to be *through tang.*

c. Tang fastened into handle, either by riveting the tang to the handle, as in the best quality knives, or by pouring a small quantity of melted resin into the hole drilled, and pressing the tang into this while still soft.

Sometimes the bone handle is made in two pieces, each piece called a *scale*, the tang is flat, and the two scales are riveted to the tang.

Some of the best knives have what are called *balance* handles. In these knives the handles are made heavier than the blade, and so when they are placed on the table they rest on the shoulders. The blade is thus kept from touching the table-cloth.

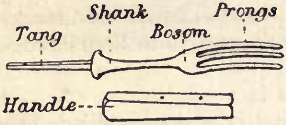
Second—THE FORK.

I. Parts.—Let children examine the fork and point out the parts, giving names where able, rest to be supplied. The parts are, the prongs, the bosom (*i.e.* that portion immediately above the prongs)

—the shoulder, the shank (*i.e.* the portion between the shoulder and the handle)—the tang, and the handle.

The qualities will depend on the particular kind of fork.

II. Manufacture:



a. Forged out of a rod of steel about ⅜ of in. square. Tang, shoulder, and shank first formed by the workman on the anvil. These are next cut off, leaving at one end about an inch of the square rod.

b. The workman next makes the square piece red-hot, and hammers it out to the length of the prongs. This piece thus drawn out is called the *mood* or *mould.*

c. The mould is made red-hot, placed between two dies and pressed, thus the prongs and bosom are formed.

d. The prongs are next properly shaped and smoothed with a file, and thus the fork is prepared for

e. Grinding, polishing, and finishing. See lesson on the KNIFE.

f. When properly finished it is next fastened into the handle. See former lesson.

LESSON 6.—PINS.

The objects required for this lesson are, a number of pins of various sizes and some brass wire.

I. Introduction.—When articles of apparel, &c., have to be fastened together temporarily, a pin is used for the purpose.

A pin should never be used to hold things together which ought to be sewn, or held in their places by buttons or strings.

When pins are taken out of any article they should not be placed carelessly on the table, nor thrown on the floor, but stuck into a pin-cushion, or put into a box or tray. Children should never leave pins in any article of dress which is put away to be washed.

II. The Parts of a Pin.—Give each child a pin to examine and describe, and help them to work out the following matter:

At one end of a pin there is a *sharp point,* this pierces the materials which are to be fastened. If the point becomes blunted the pin is useless.

The part which holds the material together is called the *shank or stem:* it is straight, round, and smooth. If the shank is bent the pin is useless.

At the top of the shank is the *head:* it is round and broader than the stem. It is difficult to use a pin without a head.

III. Different Kinds of Pins.—Question the children as to the different kinds of pins which they may have seen, and so work out that there are white pins, black pins, and pins of various sizes. Some are very short and very thin; these are called "lillicuns" or "lilliputians." Some are long and thick, these are called "shawl pins" and "blanket pins." Some are of middling size, these are in common use, and are sold under the names of "short whites" and "mixed pins."

IV. The Manufacture of Pins:

1. WHEN MADE BY HAND.—To work out this head show coil of brass wire, compare it with the pin, thus lead the children to see the necessity for some operation; let them suggest the probable, then describe the exact. When one process has been worked out compare the material in that state with the finished article, and so on through all the operations, and thus work out:

a. Wire straightened and cut into shorter lengths sufficient for six pins.

b. Wire pointed.—A number of the lengths taken in the hand of the maker, who points both ends by holding them against a revolving grindstone. When properly ground they are polished. One man can point 16,000 in one hour. When the wires are thus pointed one pin's length is cut off each end, and the same process is repeated.

c. Putting on the Heads.—The head of the pin is made of a piece of thinner wire twisted about the end and riveted. It is done in the following way. Some soft brass wire is wound in a close spiral round a piece of steel wire the same size as the pins; the steel wire is then withdrawn and the coils cut up into short pieces of two or three turns each. The worker puts one piece on the stem, and with the aid of a steel die and iron bar worked by his foot fastens on the head. A quick worker can head 1500 pins an hour.

d. Cleaning and Tinning.—In the process of making the pins they become dirty. To clean them they are boiled in an acid liquor, or *pickle* as it is called. They are next boiled in a solution of cream of tartar and grain tin. The pins leave the solution white, but dull: they are next polished by being shaken in bags partly filled with bran, which is afterwards separated by winnowing. The pins are now dry, clean, and ready for papering or packing.

e. Papering.—Show a paper of pins, when the children will see that the paper has been folded by a crimping iron. The folded paper is fixed in a vice; the paperer—a girl—passes a horn comb into a heap of pins, catching up a number by the heads. One pin is thrust through each fold of the paper. The worker can paper as many as 36,000 pins a day.

Pins are also sold by weight, half an ounce or an ounce being put loose into a packet.

2. Machine-made Pins.—Solid-headed pins are made by machinery; the wire being cut into a proper length, the point being ground, and the head being formed during the process. In this way as many as 8000 pins can be made in a minute in a large factory. This is equal to 6,000,000 per day of twelve hours.

Supposing each pin to be one inch in length, if the number thus made were placed in a line end to end, they would reach nearly 97 miles; and if the same number were made every working day in a year they would reach 30,361 miles, or 4361 miles more than round the world at the equator.

Historical Note.—Pins such as those now in use seem to have been unknown in England till about the middle of the fifteenth century. Before that time the pins used were much larger than those used at the present day, and were made of ivory, bone, boxwood, and a few of silver. In 1625 the manufacture was introduced into Gloucestershire, and which is at the present day the chief seat of the industry.

Lesson 7.—NEEDLES.

I. Parts.—Supply each child with a needle, and let them mention the parts, as point, shank, head, and eye. Compare these with corresponding parts of pin.

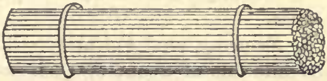
II. Manufacture.—In giving this lesson pursue the same method as in the previous, and so work out:

1. *The Raw Material.*—Soft clean steel wire received by the needlemaker in coils of various sizes and weights, and numbered to correspond with certain slits in a small steel plate called a gauge: of these number 1 represents a wire $\frac{1}{22}$ of an inch in diameter: number 12 a wire of $\frac{1}{100}$ of an inch. Each coil is 16 feet in circumference, contains sufficient wire to form several thousands; size No. 6 would suffice for 60,000 needles.

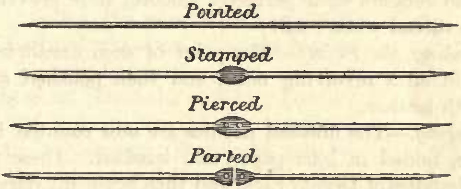
2. *Cutting the Wire.*—The coil of wire is first cut into half, and this again into the length required to make two needles. Each *end* as it is called being about three inches long.

3. *Straightening the Ends.*—Several thousands of these lengths are

made into a bundle; fastened at each end by a ring of steel, and heated to redness in a furnace. While red-hot, the bundle is laid on a flat iron plate and rubbed backwards and forwards with a steel bar slightly curved. (This process can be illustrated by placing a piece of bent wire on a smooth board, and rubbing it backwards and forwards with the back of a brush.)

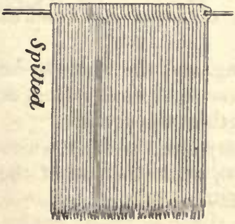

A Bundle of Straightened Wire.

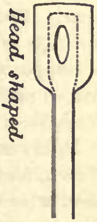
4. *Pointing.*—The grinder takes from fifty to sixty wires between the thumb and forefinger of his right hand, and as he presses them against the grindstone he causes all the wires to roll round, and thus each is pointed. One end having thus been pointed, the workman reverses the wires, and does the same to the other end. As the grinding has to be done by the dry process, the operation was formerly one of the most injurious of all industrial occupations, the fine dust being inhaled into the lungs, caused the death of the workman in a few years. It is now by a simple mechanical contrivance rendered quite innocuous. The grinder sits in front of the stone on a hollow seat, and this forms an air-shaft open towards the stone. As soon as the stone is set in motion a blast of air is forced through the shaft and this carries away the injurious dust.



5. *Stamping for the Eyes.*—The wires thus sharpened at each end are next taken to the *impressing machine*, which forms the two grooves, a small cross cut between them, and punches the two holes for the eyes.

Each wire now resembles two rough unpolished needles united together by their heads. They are next separated. A number are *spitted* on a piece of wire held firmly in a vice, and have the heads filed into shape.





6. *Hardening and Tempering.*—The needles are next made red-hot, and suddenly cooled by being plunged into cold water or oil. They are now brittle, and so have to be *tempered* by being slightly heated, and suddenly cooled. By this process the needles are rendered less brittle.

7. *Scouring and Polishing.*—The tempered needles are weighed out into lots of about 500,000 each, and after being shaken so that they lie side by side, they are laid on a square piece of canvas, and a quantity of sand and emery powder being mixed with them they are corded up very securely into a long roll. A number of these bundles are placed in the scouring machine, where they are rolled for eight or ten hours. When polished they are scoured in saw-dust to remove all the dirt and grease. They are next polished by being rolled for some hours in putty-powder and oil; they are then washed in soft-soap and water, and finally dried in saw-dust.

8. The saw-dust having been removed by winnowing, the needles are taken to a workman, who sorts them and turns all the heads one way. These processes are called *evening* and *heading.*

9. *Drilling.*—The sorted and arranged needles are now sent to the *driller*, who takes each separate needle, inserts into the eye a fine drill, and so renders each perfectly smooth, thus preventing their cutting the thread when used.

10. *Finishing the Points.*—The point of each needle is now carefully ground on a revolving hone, and then polished on a wheel covered with leather.

11. *Papering.*—The finished needles are now counted into sets of twenty-five, folded in blue paper, and labelled. These papers are made into bundles of twenty each, and then again into larger packets which contain 20,000, 40,000 or 60,000 needles.

Locality of the Needle Manufacture.—The chief seat of the needle manufacture in this country is Redditch in Worcestershire. It is computed that Redditch and its neighbourhood supplies yearly the enormous number of over *three thousand six hundred millions of needles.*

Supposing each needle to be one inch long, and the whole to be placed end to end, they would form a line over 58,139 miles long, or more than twice the circumference of the earth at the equator.

It is computed that 2¼ millions of ordinary sized needles weigh 3 cwt., and are worth rather more than £200, while the cost of the steel wire of which they are made is about £14.

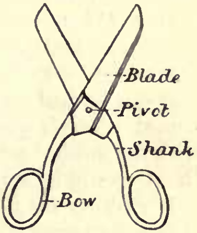
LESSON 8.—A PAIR OF SCISSORS.

The objects required for this lesson are, one or two pairs of scissors, and some thick and thin material to cut.

I. Introduction.—Let a child pick up from off the table a pair of doll's shoes, and another child a pair of scissors. The class will see that the child who picked up a pair of shoes had to lift two separate objects, while the other, who picked up a pair of scissors, lifted but one object. It will be thus seen, that what is called a pair of scissors is really one object. But then the one object is made up of two pieces fastened together in the middle, and this is why it is called a pair.

II. Parts.—Direct the children's attention to the scissors as a whole, when they will discover that although the two pieces of which it is composed are fastened together in the middle they can be moved. Each piece is called a *limb.*

Children to examine the limbs and thus discover that they have parts. First, the parts in which the thumb and finger is put when the scissors are being used. These are called the *bows.* Second, the parts which are used to cut the material; these are called the *blades.* Third, the parts between the bows and the blades; these are called the *shanks.* Fourth, the part which keeps the blades together; this is called the *rivet.* The limbs can be moved on the rivet, and because of this that part is also called the *pivot.* The rivet is a screw, and consists of three parts, the *head,* the *neck,* and the *thread.* The place made in the limb to receive the head of the screw is called the *shelf* or the *twitter bit.*



III. Qualities.—Question as the nature of the material of which the scissors is made. Steel: a substance made from iron. The iron was found in the earth, and so a *mineral.* Next work out the appearance of the object as a whole. It is bright, smooth, and hard.

Now let the children describe the blades. They are tapering and pointed, but one blade is more pointed than the other. Each blade has two faces, the outer one is curved, the inner one is flat; also two edges, one of which is sharp and the other blunt. The shanks have two faces, both of which are curved. The bows are round, and have two faces, the inner one is a little more curved than the outer one.

IV. Kinds and Uses.—Show children several kinds of scissors, and lead them to see the uses to which each is put. Thus they will learn that though the varieties of scissors are very numerous, the principal sorts are:

Button-hole and Nail Scissors: both very small, and not fitted for cutting either thick material or large pieces of thin.

Cutting-out and Draper's Scissors: both fairly large, and fitted for cutting large pieces of moderately thick material.

Tailor's Scissors: sometimes called *shears.* Large and strong scissors, and fitted to cut both large and thick material.

By experiment, lead the children to discover that tough and thick material, such as leather, cannot be cut with the scissors, but a knife must be used for the purpose.

V. Where made, and how.—Tell the children that a pair of scissors is called a piece of cutlery, and the man who made them a cutler.

In the time of Queen Elizabeth London was the chief seat of the cutlery trade. At the present time, however, by far the greater part of cutlery produced in England is made at Sheffield.

HOW MADE.—Provide two bars of steel a little larger than a pair of scissors, and by comparing these together the children will see that such pieces of metal must pass through several processes before they can be made into a pair of scissors. As each of the processes named below is worked out, compare the piece of steel in that state with the finished article, and thus lead the children to suggest each: thus they will become active agents in the lesson. The processes are:—

1. *Forging the Blade* at the end of a small bar of flat steel. This is done by means of a hammer and an anvil. Each blade is forged without reference to any other, and yet the workman is able through long practice to forge any number singly, and yet sufficiently alike in size to allow them to be afterwards paired.

When the blade has been shaped it is then cut off, with enough of the metal to form the shank and bow.

2. *Forming the Bow.*—This is done by punching a hole in the opposite end of the bar to the blade. The hole is made large enough to admit the point of a small anvil, or *beck-iron,* upon which the bow is worked out with a hammer.

3. *Shaping the Bow and the Shank.*—This is done by filing. The joint is now squared, and the hole is bored and fitted for the rivet.

4. *Grinding the Blades* to get them into proper shape. This is

done by means of very hard stones, which are made to revolve very rapidly by steam-power. The blades are held against the stones, and the rough surface of the stone rubs off the steel.

5. *Finishing the Shanks and Bows.*—This is done by first smoothing them with very fine files, and then burnishing them with fine emery powder and oil.

6. *Sorting and Fitting the Blades into Pairs.*—This is done by a man called the "putter together," who sorts the blades, and when he finds a pair which will work together, or "walk and talk well" as he calls it, he screws them together. Each pair is then bound round with fine wire, the rivet taken out, and the blades and shanks are hardened. This is done by making them red-hot, and while still red plunging them into cold water or oil.

7. *Finishing the Blades.*—This is done by first grinding them into proper shapes, and then fastening them together so as to make them work properly. The bows and other parts are now rubbed with fine emery powder and oil. The shanks are also ground and polished.

8. *Fastening and Finishing.*—The limbs are now riveted together, the edges of the blades sharpened, or "whetted" as it is termed; and all parts are burnished with polished steel tools.

LESSON 9.—A SILVER THIMBLE.

I. Introduction.—When a little girl is learning to sew she has to use a *needle* and *thread.* She has to push the needle through the stuff with the middle finger of her right hand, and to prevent the needle from pricking her finger she *puts a thimble on it,* and the thimble is like a cap to cover the top of this finger.

II. Kinds of Thimbles.—There are many different sorts of thimbles: very small ones for little children, and larger ones for big girls and women. Some thimbles are made of brass, others of steel; some of silver and others of gold. Only very rich ladies use gold thimbles, because they cost so much money. Steel thimbles wear for a much longer time than any others. Brass thimbles are very cheap, but they are not so good to wear as any of the other kinds, because they are apt to injure the flesh. Some thimbles are made of bone, others of ivory, both of which are animal substances.

III. Parts and Qualities.—Most little girls are pleased when they have a silver thimble of their own. The one which is now on the table is a silver thimble; it shall now be described.

Because it is made of silver, which is a metal, it is said to be a mineral substance. The thimble is white, bright, and hard. It is also *round* and *hollow,* and a little narrower at the top than at the bottom.

Round the bottom is a *rim,* which is a little thicker than the other parts. The rim keeps the thimble from hurting the finger.

Above the rim is the *border,* which is smooth and ornamented. Between the rim and the top is the *body;* this is curved.

The inside of the thimble is smooth; but all parts of the outside, except the border, are rough. The roughness is caused by little holes which are placed in rows. These little holes keep the needle steady while it is pushed through the work.

LESSON 10.—A HAIR-BRUSH.

The objects required for the lesson are, a common hair-brush, some bristles, unsorted and sorted, a small hank of thin brass wire, some pieces of wood, and a picture of a lathe.

I. Introduction.—The hair of the head is a great ornament to a person when it is clean and smooth; but when it is ruffled and out of order it does not look at all nice. To keep the hair in proper order it has to be combed and brushed. The lesson will be on the brush only. (For a comb see lesson on HORN.) Provide an ordinary hair-brush. Children examine it and so work out:

II. The Parts of a Brush.—The brush is made of *bristles* and *wood;* the whole of the wooden part is called the *stock.* The bristles are arranged into tufts and fastened into the stock with *brass wire.* The part of the stock which has no bristles fastened into it is called the *handle.* The back of the stock is covered with a thin piece of wood which is called the *veneer.*

III. The Processes in Brush-making.—When a brush-maker wishes to make a hair-brush he first buys a piece of wood about the size of the brush that is needed.

1. *The Stock.*—This piece of wood is then cut to the *exact size* and *shape* of the *stock* of the intended brush, and it has a narrow part to form the handle and a broad part to receive the bristles.

When the stock is thus shaped the under surface of it is smoothed and polished. When this has been done a number of small holes are made in the broad part of the stock. These holes are called *knot-holes,* and they are made with a thin sharp steel instrument called a *drill,* which is turned quickly round and round in a machine called a *lathe.* When all the holes have been drilled in the stock, it is ready for the bristles to be *drawn in,* as it is called.

2. *The Bristles.*—The bristles which are used are the coarse hairs which grow on the back of the large *swine* (pigs) that live in foreign countries. When the pigs are killed the bristles are plucked out of the skin, tied up in bundles, and sold to the bristle merchant.

When the bristles are bought of the merchant they are of different lengths, thicknesses, and colours, and they are called by different names according to the colour, as black, gray, yellow, whitish, and very white, or *lillies,* as they are called. As it would not do to put them into the stocks in this state, they are *sorted,* all the long ones being put together, and all the short ones together, and all those of the same colour. While sorting them the man *lays them straight* and puts the thick ends—or *root ends,* as they are called—together. Some brushmakers sort the bristles themselves, others buy them already sorted. Either before or after they are sorted the bristles are thoroughly cleansed.

3. *Filling-in the Bristles.*—In filling the stock, the brushmaker takes in one hand about half as many bristles as will fill the *knot-hole,* passes their root ends through a *loop* of thin brass wire. With his other hand he passes them double through the hole from the back of the stock. He then pulls the wire tightly, and so *draws* the two ends of the bristles together so as to form a *little bunch or tuft.* The wire is then drawn through another hole, and the same thing done as before, and the same again until all the holes are filled with bristles.

As the bristles are too long and their ends are not even, the brushmaker now cuts them to the proper length and makes all the ends even, and so fits it for the use to which it is to be put.

4. *Finishing.*—As the wires which are used in drawing in the bristles are seen on the back of the stock, and make that part rough; and as the wire might get broken and so let the bristles fall out, the back is covered with a thin piece of wood called the *veneer.* The veneer is fastened on to the back of the stock with glue. When the glue is hard the veneer is cut to the shape of the brush; all parts of the handle and the veneer are next polished, and then the brush is said to be finished and is ready to be used.

The stocks of some brushes are made of bone, others of ivory. In some the back of the stock is covered with a veneer of ivory or tortoise-shell. All such brushes are rather expensive.

LESSON 11.—DIFFERENT KINDS OF BRUSHES.

I. Kinds.—Let the children name the various kinds of brushes they may have seen and purposes for which used, and so bring out the different sorts used, as—

Brushes used for domestic purposes, for sweeping, scrubbing, and dusting.

Brushes used by workmen for white-washing, painting, and varnishing.

Brushes used by artists in painting pictures.

Brushes used for personal purposes, as tooth, nail, and flesh.

II. Materials of which composed. — Have several kinds examined. Children will discover that some are made of stiff bristles and some of soft hair. Others are made of various vegetable fibres, as cocoa-nut fibre, bass, and some of strips of whalebone. Give the following information :— For the smaller kinds of brushes, known as *pencils*, feathers are sometimes employed, but more usually the carefully selected hair of the camel, badger, squirrel, goat, polecat, sable, and other fur-giving animals. When using up camel or sable hair the greatest care is taken to prevent waste of material, as a double handful of the latter kind is worth £20.

III. Particular Sorts of Brushes.—From an examination of one or two specimens the children will discover that all brushes can be arranged into two distinct classes, those which consist of a single tuft of hair or bristles, and those which consist of a number of such tufts. The former are called *simple* brushes, and the latter *compound.*

1. SIMPLE.—Take the simple brushes and examine them, when the children will see that these consist of two kinds—

a. Round, such as those used by painters and artists.

b. Flat, as those used for white-washing.

2. COMPOUND.—Draw the children's attention to the compound stock brushes as to the way in which the bristles are inserted, and thus work out that the compound brushes can also be divided into two sorts:

First, those in which the bristles are merely *set* in the holes of the stock and fastened.

Second, those in which the bristles are *bent double* so as to form loops through which the wires are passed for the purpose of "drawing" them into place in the holes of the stock.

Compound brushes are now made by machinery. The machine, which is called the Woodbury Machine, is so constructed that it can bore the holes, form the tufts of bristle, insert them in the holes of the stock, and fasten them with the wire. The machine is not used so much in England as it is in America.

LESSON 12.—A CLOCK.

The clock is supposed to be an ordinary American clock in an oblong case.

I. The Parts of a Clock.—Tell the children the subject of the lesson. Call their attention to the parts of the clock, and lead them to observe carefully and describe accurately what they see: thus working out the following matter.

The clock is placed in a *case*, which has a top, a bottom, a front, a back, and two sides. The front of the case opens like a door; it has a frame and a pane of glass.

The clock has a face, called the *dial.* On this are painted two circles, one inside the other, and between these a number of thin short lines, sixty in all, placed at equal distances from each other. Just below the inner line the figures one to twelve are painted; between each figure there are five of the short lines.

In the front of the face is a hole—or two, as the case may be—through which the key is put when the clock needs winding up. In the middle of the face there is another hole through which the pivot is put on which the hands turn. One hand is longer than the other.

Behind the face are the works of the clock: these are held together in a frame, which is fastened to the case.

II. The Use of the Parts.—The case holds the clock, and keeps the dust from getting into the works. The door can be opened when the clock wants winding up, or the hands need to be moved.

The twelve figures denote the twelve hours of the day, and the little lines between the figures indicate the sixty minutes of the hour.

The short hand points out the hour of the day, and the long hand tells the minutes of the hour. The long hand moves once round the face in an hour, the short one moves from one figure to another in the same time, so that it takes the short hand twelve hours to go once round the face.

III. Qualities.—The case is made of wood: it is oblong, smooth, and bright. The face or dial is made of a metal; it is square (or round), white, smooth, and hard.

The lines round the face are circular, black, and thin. The figures and the minute lines are black. The hands are made of steel, they are of a bluish colour, smooth, bright, thin, tapering, pointed at one end, and rounded at the other. In the rounded end is a square hole in which the pivot fits.

Take off the case, call attention to the works, when the children will see that the wheels of the works are numerous and of different sizes. They are made of brass, and circular, and toothed. The spring is made of steel, it is of a bluish colour, flat, smooth, thin, and elastic.

IV. How to tell the Time of Day by the Clock.—Provide a large model of the face of a clock with movable hands, and work out the following:

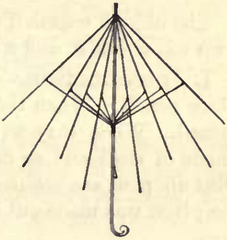
When the long or minute hand points to the figure twelve, and the short or hour hand to any of the figures, we know that the hour of the day is that to which the hour hand points. When the long hand points to any of the minute lines, and the hour hand is between any of the figures, we know that it is so many minutes past the hour. Thus if the minute hand stands at the figure 3, we say it is a quarter past the hour, because between the figure 12 and the figure 3 there are fifteen minute marks: and fifteen are a quarter of sixty. When the minute hand stands at 6, we say that it is half-past the hour, and when at 9, three quarters past the hour, or a quarter to the next hour.

V. Different Kinds of Clocks.—Question the children on what they may have observed respecting clocks, and thus bring out that some clocks have round cases, others square cases. Some clocks are small, others large, and have weights. Some again have bells attached on which they strike the hours and the quarters. Those large clocks which are placed in towers and other large buildings are called *Turret Clocks* and *Church Clocks.*

LESSON 13.—A SILK UMBRELLA.

I. Introduction.—As Mary was leaving her home to go to school, her mother called her back to tell her that, as there was every appearance of a wet day, she must take an umbrella with her. As Mary did not possess such an article, her eldest sister lent her hers, a nice silk one which she had lately bought. Here is one like it, which shall now be described. Let the children examine the object and name the parts known; give proper names to those not known.

II. Parts, and their Uses.—The part which is taken in the hand when it is being used is called the *handle;* this is joined on to the *stick* (in some umbrellas it is the end of the stick). When in use the umbrella is opened, and the part which is spread out and which keeps the *rain* off is called the *covering;* this is stretched over the *frame,* which is called the *stretcher.* The frame is made of several pieces of steel wire, each piece is called a *rib.* Each rib consists of two pieces, a long one and a short one. The long pieces really form the frame on which the covering is fastened; the short pieces serve to keep the frame extended when the umbrella is being used. The ribs are fastened at both ends to small pieces of iron called *ferrules.* Near the top and near the bottom of the stick is placed a *small wire spring,* and in the ferrule into which the short ribs are placed is a *slit.* When the umbrella is opened, the spring at the lower end of the stick projects beyond the ferrule and keeps the framework up. When the umbrella is closed the spring at the top end of the stick enters the slit and keeps the umbrella shut. On the outside of covering, near the top, is a button and a small piece of elastic fastened to it. These are to keep the umbrella closed up when it is not in use. At the end of the stick another ferrule is placed, this is put there to keep the stick from wearing away when it is put on the ground.



Frame of Umbrella.

III. Qualities of the Materials.—The stick and the handle are made of wood: the stick is cylindrical, smooth, and polished. Near the top and near the bottom there is a little slit in which the spring is put. The handle is bent. The covering is made of silk: it is coloured (brown), soft, thin, and pliable.

The ribs are made of steel; they are thin, grooved, hard, rather brittle, and blackened. The springs are made of steel wire, they are curved and hard.

IV. Different Kinds.—There are many different sizes and sorts of umbrellas. Some of those used by women are smaller than those used by men. Very small ones used to keep the sun off the face are called *parasols.* Very large ones, used by people when they have to ride in the rain, are called *carriage umbrellas.*

Common umbrellas are covered with a cotton substance called *gingham;* the better sorts with a woollen substance called *alpaca;* the best are covered with *silk.*

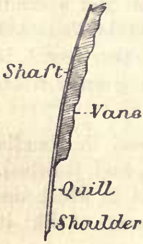
V. The Care of Umbrellas.—When the umbrella is not in use it should be neatly folded and put into a case: when wet it should not be folded up, but opened and dried. A good umbrella is an expensive thing, it should therefore be well cared for.

Lesson 14.—A QUILL PEN.

The objects required for this lesson are, a newly cut pen, one or two whole quills, and a picture of a goose and a swan.

I. Introduction.—When children write on slates they use a slate pencil. When they write on paper they sometimes use a lead pencil. When they write in a copy-book they use a pen, which is made of steel and so called a steel-pen, and this fits into a holder. But all pens are not made of steel, the one on which the lesson is to be given was made out of the feather of a bird, and is called a *quill pen.*

II. Parts.—The pen now to be examined, and as its parts are pointed out by the class give the proper names. The part which is used to make the marks on the paper is called the *nib.* Let a child press the nib against his thumb nail, he will see that *it is split* in the middle, so that the nib is really in two pieces. On either side of the split there is a little projecting part, these are called the *shoulders.* The part which is cut to form the nib and the shoulders is called the *quill.* The part above the quill is called the *shaft.* Have a shaft cut open. The children will see that it is filled with *pith.* On one side of the shaft there is a feathery part, this is called the *vane* or beard. Cut it off and have it examined. Children will see that it is made up of a number of small flat pieces: these are called *barbs.* (See lesson on FEATHERS.)



III. Qualities.—Require the children to look at the pen again, and say all they can about each part, and so work out that—the nib is pointed and split into two parts; it is flexible. The quill is cylindrical, hollow, nearly transparent, bright, hard, elastic, light, and of a pale yellowish colour.

The shaft is four-sided. It is largest near the quill, and gradually lessens in size to the top. It is slightly bent, and covered with a horny substance like the quill. Two of the sides are grooved. The whole of the shaft is white, smooth, shiny, hard, stiff, and light.

Next, let the shaft which has been cut be examined, and children describe the pith. It is soft, spongy, light, and elastic. It is also very white. Next, children examine the vane. It is white, light, and soft. The barbs are flat and hooked.

IV. Whence obtained.—Question as to where the quill, of which the pen is made, was taken. From a bird. Show pictures of two birds whose feathers are used—the goose and the swan. Tell that it is only the large feathers out of the wings, generally the second and third, which are used for pens. The feathers of the crow and turkey are also used, the former for drawing and the latter for that particular kind of writing called engrossing.

The feathers are prepared and the nibs cut by a man called a pen-cutter. He uses a very sharp knife to cut the nibs. When the pens are made they are tied up in bundles and sold to the stationer, who sells them by the bundle or at so much each. A good quill pen can be bought for a halfpenny.

For further information on quills, for elder children, see lesson on FEATHERS.

LESSON 15.—A PENNY AND THE OTHER BRONZE COINS.

The objects required for this lesson are, specimens of the coins used in this country, and a sufficient number of pennies for each child in the class to have one to examine.

I. Introduction.—Tell the children that the lesson will be on some of the pieces of money which are used, the class to name all the coins in use, beginning from the lowest in value to the highest. Arrange them into groups according to the kind of metal of which they are made. Thus,

Bronze: Farthing, Halfpenny, Penny.

Silver: A Threepenny piece, a Fourpenny piece, a Sixpenny piece, a Shilling, a Florin, a Half-crown, and a Crown.

Gold: Half-sovereign, a Sovereign.

II. Description of a Penny Piece.—Let every child have a *penny* to examine, and by careful observation lead them to describe it thus. A penny is the largest of the Bronze coins. It is circular, and about an inch broad. It has two faces: each face has certain marks on it which show that it is a piece of English money. On one face there is the Queen's head—this is called the *image*, and round the outer part of the face there are words and letters, the whole of these is called the *superscription*, and consists of *Victoria*, the name of the present queen; *D.G.*, which are the first letters of two Latin words, *Dei Gratia*, and which mean "By the grace of God;" *Britt.*, a part of another word meaning Britain; *Reg.*, a part of the Latin word *Regina*—"Queen"—and the letters *F.D.*, the first letters of two other Latin words which mean "Defender of the Faith." So the superscription is, "VICTORIA, BY THE GRACE OF GOD, QUEEN OF GREAT BRITAIN, DEFENDER OF THE FAITH."

On the other side, or the *reverse* as it is called, there is a *figure of a woman* in a sitting posture. She has a helmet on her head: her right hand is resting on a shield, and in her left hand there is something like a long toasting fork: this is called a *trident*. The figure is called *Britannia:* on the right-hand side of the figure there is a ship, and on the left a lighthouse. These are put there to represent Britain's power on the seas.

Round the outer part of the face are the words "ONE PENNY," and at the bottom the date of the year when the coin was made.

On the *Halfpenny* and the *Farthing* there are the same figures, words, and letters as there are on the penny, except the words which show the value of the coin. You know, of course, that a penny is worth two halfpence, and a halfpenny is worth two farthings. So then you see that a penny is worth four farthings. They must remember this when they are spending money, and teach their younger brothers and sisters to know it also.

III. The Metal of which it is composed.—Tell the children that the bronze used for these coins is a metal, but it is not found as bronze; it is made by mixing together a certain quantity of copper and tin. Show both the metals. This is done at a place called the Royal Mint, where, in the year 1891, 17,955,840 penny pieces were made.

HOW MADE:

1. *Melted.*—When the metals are melted together, and so get well mixed, the bronze, as it is then called, is poured into an iron mould and left to get cold. When quite cold the mould is opened and the bronze taken out: the piece is now called an ingot. Show a thick piece of copper, which they will fancy is the ingot of bronze. Com-

pare it with a penny, children will see that it is much too thick. What then must be done to it?

2. *Flattened.*—It must be made thinner. Tell how this is done. It is passed between a pair of large steel rollers in a machine called a *flattening* mill. The rollers can be pressed together just as close as the man who has charge of them pleases. The ingot is passed between these rollers many times, and every time it is made a little thinner, because the rollers are pressed closer together. Suppose that the bronze is rolled out to the proper thickness for the penny. It will now be a long strip of metal, not much like a penny. What must be done?

3. *Punched.*—It is now taken to another man, who cuts out with a punching-machine round pieces just the size of the penny. Show a piece something like one. Children will see that it is not quite like a penny yet. It wants all the marks which show that it is a proper coin.

4. *Stamped.*—The pieces are next taken to the stamping-room, and each is put into the stamping-press, and with one blow of a heavy weight all the letters and figures are made on both sides at once, and now it is a penny.

5. *Cleansing.*—But with all the pressing and stamping it has, if we may so speak, got a very dirty face. The next thing which is done then is to wash it and make it bright.

The halfpenny and the farthing are made in the same way as the penny. During the year 1880, 2,423,465 halfpence and 1,824,710 farthings were struck at the Royal Mint.

IV. What can be Purchased for one Penny.—Having learned what is on a penny and how it is made, in the next place let children say what they can buy for the coin; and first, *as to food,* a penny will pay for one or other of the following things:—an egg, an ounce of butter, two ounces of cheese, a quarter of a pound of loaf sugar, half an ounce of tea, a small loaf of bread, an ounce of coffee, an ounce and a half of bacon, two pounds of salt, and many other things which perhaps they will remember.

Things *which are used in the house.* Thus a penny will buy either a candle or even two little ones, a quarter of a pound of soap, a pound of soda, a little starch, some blue, two boxes of matches, and many other things which are useful.

Then, again, a penny will buy either of the following things:—a pretty picture-book, some writing paper and envelopes, a pen in a holder, a lead-pencil, a bottle of ink, a postage stamp, and very many other things which will both instruct and amuse children.

LESSON 16.—A BOOK.

The Reading Book of the class may form the subject of the lesson.

I. The Parts of a Book.—Let each child examine the book and name the parts known. Give proper names to those parts not known. Thus work out the following points:

1. *The Case or Binding.*—The *case* in which the *leaves* of the book are fastened is called the *cover* of the book, or the *binding:* this consists of two *side boards* and a *back.* Each side board has *two faces,* an outer and an inner, *four edges* and *four corners.* The back has the same parts as the boards, and the same number of them.

The outside of the case is covered with cloth or leather; this is coloured and ornamented, and on it is stamped the name of the book —this is called the *lettering.*

2. *The Book proper.*—The book is made up of a number of *leaves of paper.* Each leaf has two sides, each side is called a *page.* All the leaves are fastened together with strong thread, this fastening is called the *stitching.* When the leaves are all stitched together, the stitching is covered with a piece of cloth, and the whole is fastened to the case. The *book is then said to be bound.*

The first leaf is a *coloured one,* the duplicate of one fastened to the side boards; this is called the *waste paper.* Next to this is the *title page,* on which is printed the *name of the book,* the *writer* of the book, of whom it can be bought or the publisher. On the third leaf is printed the reasons why the book was written: this is called the *preface.*

The leaf that comes next to the preface contains a list of the subjects in the book, with the number of the page at which each subject commences. This list is called the *table of contents.* In some books the contents, more fully drawn out and arranged in alphabetical order, are given also at the end. This is called the *index.*

Next to the table of contents comes the *commencement of the book.* At the top of each page, in the middle, is printed the *subject,* and at the outside corner the *number of the page.*

Each page contains *lines of print.* At the top, the bottom, and at each side of the page there is a space without any print. This space is called the *margin.* The lines of print are made up of *letters,* which form *words:* these words are arranged in *sentences.* Each sentence begins with a capital letter and ends with a full stop. The sentences are arranged in *paragraphs:* the last line of the paragraph is not carried all across the page of print.

II. The people concerned in producing a Book.—The man who writes the subjects which are in a book is called the *author of the book.* The man who arranges the *letters,* or *types,* as they are called, into words, &c., goes by the name of a *compositor;* and the man who makes these words, &c., to appear on the leaves of paper, is called the *pressman* or *printer.*

III. Arranging the Types.—The compositor gets the manuscript, or "copy" as he calls it, of the book supplied by the author, and proceeds to arrange types in words and lines to correspond. When a sufficient number of lines has been set up they are formed into a page, and when enough pages have been prepared to fill a sheet of the paper to be used, they are put together into a frame or a pair of frames, called *chases.* This is done in such a way that when the printed sheet is folded over and over the pages of print will follow each other in due order.

Notice the confusion apt to arise from the double use of the word *sheet,* which is used to indicate both (1) the successive portions of a book printed at a time, and (2) the sheets of paper that are printed of each such portion.

IV. Printing the Sheets.—The pressman puts some *printing ink* on the *pages of type* arranged in the frame, then places a sheet of paper on them, and presses it in the press. By this operation the ink on the type is transferred to the paper, and the forms of the letters appear in black. When one side of the sheet has been printed, the other side is placed on another frame which contains other portions of the subject of the book, so that when it finally leaves the press it is printed on both sides.

The number of sheets printed from each frame depends upon the number of books which are to be published. The particular number is called an *edition,* five hundred, a thousand, or more as the case may be.

LESSON 17.—A BOOK—(*Continued*).

Having obtained from a printer a sheet in the state in which it leaves the press, compare it with the bound book, when the children will see that the former is rough, while the latter is smooth and somewhat shiny. Tell how this change is effected.

V. Finishing the Printed Sheets.—On coming from the press sheets are first dried by being hung on poles for a length of time. When dry they are placed singly between glazed millboards, and submitted to great pressure.

Tell that the pressman prints, or "pulls off" as it is called, the number required of each sheet and places them in a heap, so that if the books should be made up of ten or twenty sheets, there will be as many heaps, each heap containing as many sheets of paper as there are to be books in the edition. When the sheets of printed paper are dried and smoothed they are placed in heaps again. The children will thus be able to say what must next be done, namely, arranged into distinct books: this is called *gathering* them. In this state they are delivered to the *binder*.

VI. The Binding of the Book.—Take a book to pieces carefully, and let children compare a printed sheet with it, when they will see the necessity for the various operations as each is mentioned, illustrate it, and thus work out the following processes:—

1. *Folding* the sheets so as to make the pages follow each other in order.

2. The sheets of the book *collated*, that is examined to see that they follow in their proper order. Point out to the children the little letter or figure at the bottom of the first page of each sheet, this is called the *signature*, and indicates the order of the sheets in the book.

3. When the books are thus *made up*, they are made solid by being placed in a powerful press.

4. Small indentations are next made in the back of the folded sheets to prepare for the sewing.

5. The sheets are next sewed to cords or tapes stretched upright on a frame, the ends of which cord or tape form the principal attachment to the case to be afterwards put on.

6. On being removed from the sewing-frame the book receives what is called its *waste papers*, that is, the blank sheets which are found at the beginning and end of the volume, these papers are pasted to the back on both sides.

7. The book is now *trimmed* by being cut on the edges by a sharp knife.

8. In the next place the back is covered with a thin coating of glue to give it a certain degree of firmness.

9. The back of the book is now rounded by a machine, and is then said to be *backed*. When this has been done a piece of canvas is pasted on the back, and it is now ready for the *cover* or *case*.

10. The case consists of *cloth* or *paper* pasted on two pieces of thick material prepared for the purpose and called *boards*, the distance of the boards from each other being equal to the thickness of the book.

To this case the book is attached, chiefly by pasting on it the ends of the cords and the waste papers at the ends. The case has the title of the book printed or stamped on it before the book is fastened in.

11. When a book has to be bound in *leather* the boards are first attached to the book by the cords, and then the leather is pasted on. When the leather covers the whole book it is said to be *full bound.* When the leather only covers the back and the corners it is said to be *half bound.* After the leather has been fixed the title, or *lettering* as it is called, and the ornamentation, are done by a man called a *finisher,* generally by hand, but sometimes by a press.

The finished books are now sent to the publisher, who distributes them to the *trade,* as it is called, in other words, to the booksellers.

VII. The Size of Books.—Provide several sets of books of different sizes, when the children will see that there is a similarity in them. Take one or two old volumes to pieces, when the children will see that the book is made up of a number of sheets, and that each sheet is folded a certain number of times, so forming the same number of leaves.

By means of a sheet of printing paper illustrate the following facts:—

A sheet being folded into two leaves or four pages, forms a book of the size called a *folio.* When the sheet is again folded, so as to make four leaves or eight pages, it forms a *quarto.* This size of book is indicated by the mark *4to.* The quarto being folded across so as to make eight leaves or sixteen pages, forms an *octavo.* This size of book is indicated by the mark *8vo.* When the sheet is folded into twelve leaves or twenty-four pages, it forms a *duodecimo* or *12mo* as it is called. When folded into twenty-four leaves or forty-eight pages, the book is called a *24mo,* &c. From observing several sheets of paper of different sizes folded, the children will see that the *size* of the book will depend upon the size of the sheet of paper which has been folded.

Tell them that for a long time printing paper was made chiefly of three sizes, respectively called royal, demy, and crown,—show these (a printer would supply them),—and according as any one of these was employed the book was large or small. These sizes are still in use, but two larger, imperial and super-royal, and two smaller, post and foolscap, have been introduced. There is a commonly recognized measurement for each of these sizes of paper, but in practice the measurement is often departed from by publishers.

The 12mo and 24mo folds are now rarely used, the 4to for larger and the 8vo for smaller books being almost always adopted.

LESSON 18.—AN UNCUT LEAD-PENCIL.

I. Parts.—A lead-pencil is used for *drawing*, and for *writing*, when what is written is not of much importance.

What is called a lead-pencil is not made entirely of lead, and is not all in one piece, but consists of two parts; an *outside part* made of *cedar-wood*, and an *inside part* made of a substance called *black-lead*. It is not lead, however, but a mineral called *plumbago*. It is the lead which is used for making the marks on the paper in drawing and writing.

The pencil, when it is bought is of a long round form, the same thickness in all parts. *It has three faces*, one curved, and two flat: the flat faces are at the ends, and are circular. Such a shape is called a cylinder, and on this account the pencil is said to be cylindrical.

The wood of the pencil is of a brown colour. Being a part of a tree it is said to be a *vegetable substance*. It is hard to the touch, but can be easily cut with a knife, and easily broken. When put into the fire it burns with a flame, and so it is said to be *inflammable*. It has a very *pleasant odour*.

On the round face of the wood, which is polished, are stamped the name of the maker of the pencil, and certain letters which show the kind of lead which has been put in, as H H when it is very hard, H B when it is rather hard, B when it is black and rather soft, and B B when it is very soft and black.

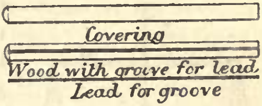
Along the middle of the wood runs a square strip of black-lead. It is of a dark gray colour, brittle, friable, and bright.

As the thin strip of lead is brittle, it would break when pressed on the paper in being used to write with; and as a thick piece would be rather expensive, and would make the fingers dirty every time it was used, a thin piece is placed between two pieces of wood which are fastened together. When a little of the wood is cut away, or when the pencil is pointed, the lead can be used without either breaking, or soiling the fingers.

II. How made.—Very few children who use lead-pencils know how they are made. It is a very simple operation, and one which even little children can understand, so it will now be described.

The pencil-maker buys the black-lead in large lumps, and the cedar-wood in thick strips. He cuts the black-lead into thin slices, and these are again cut into strips, each strip is as thick as it is broad. Then the man cuts the cedar-wood into strips of the length of the pencil he wishes to make. Two strips are required for each pencil, one a little thicker than the other.

In the thicker of the two strips, a small groove is made, just deep and wide enough to hold the strip of lead. A small quantity of thin glue is spread in this groove, and then the strip of lead is placed in it. After this, the thinner of the two pieces of wood is glued on the thicker, so as to cover the strip of lead.



When the glue is set, the wooden case is made round, smoothed and polished. After this the maker's name, and the letters H, H B, &c., are stamped on the wood, and the pencil is ready for use.

Pencils are bought singly, by the dozen, or by the gross. A gross is twelve dozens. A common pencil costs a penny; one of the best drawing pencils costs as much as fourpence, or even sixpence. A very large number of pencils are made at Keswick in Cumberland. The reason for this is found in the fact, that this town is only a few miles distant from Borrowdale, the only spot in England where plumbago is found. At the present day, however, very little of the mineral is obtained from the mines there, but it is brought to England from India, Ceylon, and from the United States of America.

Much of the imported plumbago is in very small pieces—too small to be cut into strips; it is therefore ground, refined, formed into a pulpy mass, and then moulded into the required size.

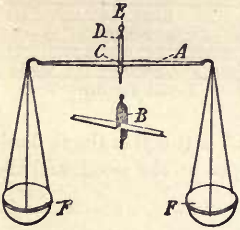
Lesson 19.—A PAIR OF SCALES.

The objects required for this lesson are, a pair of common scales such as are used by a grocer, and pictures of as many other kinds as may be convenient, also some weights.

I. Introduction.—Question out the fact that many of the articles which are needed for daily use are *bought and sold by weight*, and in order that the exact quantity may be bought *weights and scales* are used. A weight, say an ounce, or a pound, being put into one part of the scale, the tea, coffee, sugar, &c., which is being purchased, is put into the other part.

II. Parts.—Let the children examine the pair of scales, and mention the parts. When any particular part is pointed out, give the proper name, and so work out:

A pair of scales consists of an iron bar, called the *beam* A, this is rather broad in the middle, and tapers gradually to each end. In the centre of the upper edge of the beam there is a long pointed piece of iron called the *index* B. Through the middle of the beam is fixed a short steel bar called the *pivot* C, the upper side of which is round, and the under side edged. The ends of the pivots rest in the circular holes at the bottom of a fork-shaped piece of iron called the *guide* D, on the top of this is a *hook* E. When the guide is held upright, the beam can move up and down freely. The ends of the beam are curved upwards, and there is a hole at each end.



The parts in which the weights, and the articles to be weighed, are placed, are called the *scaleboards* or *bowls* F, which in the scales used by the grocer are made of copper. In each bowl there are three holes, placed at equal distances from each other.

The bowls are fastened to the ends of the beam by *chains*. There are three chains to each bowl in the scales used by the grocer, and the bowls are round. All round bowls have three chains. In some scales the bowls are square, in these there are four chains, one fastened to each corner.

III. How used.—Question children on what they may have observed as to how the scales are used, and how they know when they have received proper weight, and so work out:

In order that the scales may be true, the two bowls must be equal in weight, and when the beam is held up by the guide, the index must stand exactly upright, and be in the centre of the guide. When this is the case, the scales are said to balance each other. *When the balance is correct*, and the article placed in one bowl is equal to the weight in the other bowl, *there is just weight.* All parts of the scales ought to be kept very clean, for if any part is dirty the balance will not be correct, and then there would be *false weight.* It is wrong to have scales which do not give just weight, any shopkeeper who is found keeping such scales is punished.

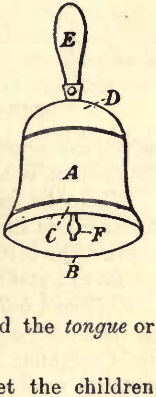
IV. Different Kinds of Scales.—When very large quantities of goods have to be weighed, large scales are used: the beams and the chains of such scales are very strong, and the scaleboards are made of wood. In some scales, as those used by cheesemongers, the beam is placed underneath the scaleboards, and the scaleboard in which the cheese or the butter is to be weighed is made of earthenware. In the scales which are used to weigh the precious metals and precious stones, the pivot on which the beam rests is so delicate that a hundredth part of a grain or even less will cause the beam to move.

LESSON 20.—A HAND-BELL (AND OTHER BELLS).

The objects required for the lesson are, a common hand-bell such as is used by a town-crier, a house-bell on a spring, and a picture of a church bell.

I. Introduction.—When it is time for children to go to school a bell is rung. There are many kinds of bells, the one that is on the table is called a *hand-bell.* The lesson will be on that bell, and the class shall learn the names of the parts and their uses, then something about other kinds of bells.

II. The Parts of a Bell.—Children to examine a bell and point out its parts. Give proper names, and so work out the following matter:

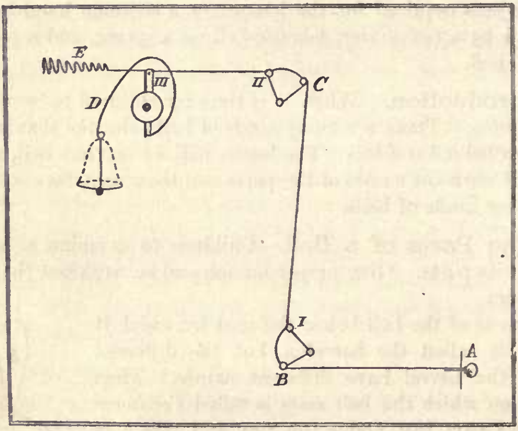


The whole of the bell below the part by which it is lifted is called the *barrel* A, but the different parts of the barrel have different names. Thus the part on which the bell rests is called the *lower rim* B, the part just above the rim, and which is the part struck to make the bell sound, is called the *sound bow* C, the top part of the barrel is called the *crown* D, that part by which the bell is lifted up and held is called the *handle* E. In bells not rung by hand this part is called the *ear.* At the top of the inside of the crown there is a small ring, in this is suspended the *nob* by which the bell is struck when it is wanted to sound: this nob is called the *tongue* or *clapper* F.

III. Kinds of Bells, and how rung.—Let the children mention the kinds of bells which they may know, show pictures, and so work out the following:

1. *Hand and House Bells.*—There are many kinds of bells, all those which are used in the same way as that on the table are called *Hand-bells;* those which are suspended in different parts of a house, *House-bells.* These are rung by pulling wires which pass from one part of the house to another. In these bells the ear is fastened to a spring, and when the wire is pulled the spring is pulled also, and when the wire is let go the spring is let go, and continues to move for some time. All the while the spring moves the bell moves, and the clapper strikes the sound bow, and the bell is said *to ring.* Illustrate how this is accomplished.

When the handle A is drawn out, the crank I is pulled forward at B, and this lowers the crank II at C, and thus moves III forward, which moves the spring D, and the spiral spring E is also drawn out. The motion of the spring rings the bell.



When the handle is let go the spiral spring will return to its former state and the cranks and wires will assume their former positions. The bell, however, will continue to ring until the flat spring D comes to a state of rest.

2. *Church-bells.*—Large bells which are hung up in the towers of churches are called *church-bells.* The part of the tower where the bells are hung is called the *belfry.* Church-bells have two *ears* or *cannons* as they are called; these are fastened to a large beam of wood, the ends of which are round, and fit into places made for them in the walls of the belfry. A thick rope is fastened to the ears of

the bell, and when this is pulled the bell is made to swing to and fro, which causes the clapper to strike the sound bow. When the bell is very large it is sometimes fastened to a wheel, and this causes it to move easier than it otherwise would. When used for the clock to strike on, the clapper is moved and not the bell, and sometimes the bell is struck by the hammer of the clock, and not by the clapper. This is the case with the large bells at St. Paul's Cathedral, Westminster Abbey, and the Houses of Parliament.

When there are several bells in a church tower, they are called a *peal*. Each bell in a peal has a different tone. When two or three of these are rung one after the other like this: *ding*, *dong*, *ding*, they are said *to chime*. When all are rung quickly in order they are said *to peal*. Church bells are rung in this way on joyful occasions, as on the queen's birth-day, or on some public holiday, or on the marriage of some great person. When one of the largest bells in a peal is rung slowly, it is said *to toll*. These uses are well described in the following lines, which were written on the wall of the belfry of the old parish church at Doncaster:—

> "To call the folk to church in time, *I chime*.
> When mirth and pleasure's on the wing, *I ring*.
> When from the body parts the soul, *I toll*.

3. *Factory and other Bells*.—Bells are used for many other purposes besides those which have been mentioned. They are rung at factories and workshops to let the work-people know when it is time to commence work, or to go to their meals, or to leave off work in the evening. Bells are also rung at the railway-stations to let the passengers know that the train is about to start (in the lesson on a RAILWAY-STATION this has been described), and at the landing-stages of wharves to announce the departure of steamboats.

Small bells are hung round the necks of sheep and goats to keep the flocks together, and in Spain, where a number of mules are used to carry goods over the mountains, a bell is hung round the neck of the first mule, and the others follow their leader as long as they hear the sound of the bell, even though they cannot see it. It must be a pretty sight to see such a string of mules coming down a mountain pass. Show a picture of these, also one of a flock of goats in Switzerland being led home in the evening to be milked and taken care of for the night. Bells are also placed on the harness of horses used in drawing tram-cars to give notice of their approach.

IV. A few of the most remarkable Bells in the World, arranged in the order of their weight:

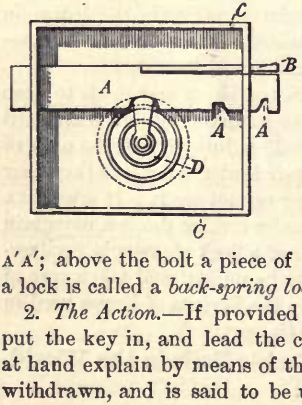
1. *In England:*
    - *a.* "Great Paul," lately cast for St. Paul's Cathedral, London.
    - *b.* "Great Ben," cast for the Palace of Westminster, but cracked, 31,360 lbs.
    - *c.* "Great Peter," in York Minster, 15,080 lbs.
    - *d.* "Great Tom," at Lincoln, 12,096 lbs.
    - *e.* The Old Bell at St. Paul's, 11,648 lbs.
2. *In other Countries:*
    - *a.* The Great Bell of Moscow, 492,800 lbs.
    - *b.* The Great Bell at Pekin, 220,000 lbs.
    - *c.* The Great Bell of Rouen, cast in 1501, 40,000 lbs.
    - *d.* The Great Bell of Notre Dame, 29,672 lbs.

LESSON 21.—A LOCK AND KEY.

I. Introduction.—Work out the fact that, in consequence of the dishonesty of some people and the improper curiosity of others, it is necessary to secure the doors of dwelling-houses, shops, banks, &c., and boxes, drawers, and other things, which contain valuable articles and important documents. The security is effected by means of locks, bolts, and bars. The lesson will be on locks and keys.

II. The Parts of a Lock, and their Uses:

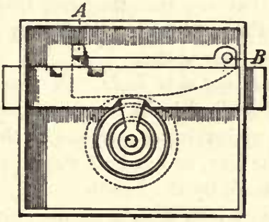
1. *The Parts.*—If possible procure a common lock, or make diagram, and point out its main parts, which are, a framework called the *rim*, CC; several semicircular pieces of iron fastened to the back plate of the frame called the *wards*, D, in the middle of which is a short bar called the *centre-pin*, and a bar which can be moved backwards and forwards when the key is turned: this bar is called the *bolt*, A; on the under edge of the bolt are two small apertures called the *notches*, A′A′; above the bolt a piece of steel called the *back-spring*, B. Such a lock is called a *back-spring lock.*

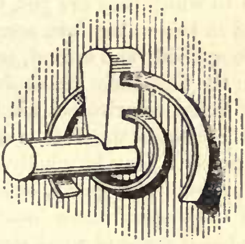


2. *The Action.*—If provided with a lock, take off the front plate, put the key in, and lead the children to see how it acts; if no lock at hand explain by means of the diagram. When the bolt is wholly withdrawn, and is said to be unlocked, one of the notches rests on

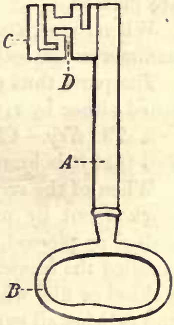
the rim CC, and the force with which the notch falls into this position, urged by the spring B, gives rise to the snapping or clicking noise which is heard. When the bolt is wholly shot or is locked, the other notch rests in like manner upon the aperture of the rim.

Tell, that for greater security locks are made with a kind of latch placed behind the bolt, with a stump or projecting piece of metal (at A). Such locks are called *tumbler locks.* (See diagram.) The tumbler moves freely on a pivot at the other end B, and is made to rise whenever the key acts on the bolt. When the bolt is wholly withdrawn the stump falls into one notch and prevents the motion of the bolt. When wholly shot the stump falls into the other notch and equally prevents the action of the bolt. It is not, therefore, until the key, by elevating the tumbler, has raised the stump out of the notch that the bolt can be moved. It will be easy to lead the children to see that by increasing the number of "tumblers" and "notches" the more difficult it will be to open such a lock with any other key than its own. Hence the invention of such locks as Chubb's and Hobbs' patent locks, and which can only be opened by a key made expressly for that purpose.





Section to show Action of Ward.



III. The Key:

1. *Parts.*—Take the key belonging to the lock, let the children examine it and point out its parts: give proper names. Thus work out that a key consists of a *cylindrical shank* A, with a *loop-shaped handle* at one end B, and a piece called the *bit* or *wet* projecting from it, at or near the other end C, in which are cut the *web* D, to allow it to enter the wards of the lock.

2. *Kinds.*—By examining several keys the children will see that

in some the shank is hollow and in others it is solid. The hollow part is called the *barrel.* Those with hollow shanks are for those locks which can be entered on one side only, as is the case in cupboard and drawer locks; those with solid shanks for locks which are entered on either side, as in all common street-door keys.

IV. Different Kinds of Locks.—Let children mention the different sorts of locks which they may have seen and the particular uses to which they are put, then tell that the manufacturer classes them in two ways: first, according to the purpose to which they are to be applied; and second, according to their shape.

In the first there are *in-door locks* and *out-door locks.* Of the in-door locks one principal kind is the *draw-back* locks for street doors. In these locks the bolt is capable of maintaining any one of three positions: it may be wholly shot by the key, or left half way out by the pressure of a spring, or be drawn back by the handle.

If the cases of these locks are made of iron they are called *iron-rim,* but if made of wood they are called *spring-stock.* In some locks the case is made of brass and the lock is let *into* the door. Such are called *mortise-locks.*

V. The Manufacture of Locks and Keys:

1. *The Lock.*—Children to examine the lock or diagram, and thus they will see that the different parts must be prepared and then fastened together.

Tell that some parts are hammered into the proper shape. Such parts are said to be forged, as in the case of the wards. Other parts are pressed.

When the separate parts are forged or pressed they are shaped by the hammer and smoothed by the file; both operations are spoken of as *filing.*

The parts thus prepared are then adjusted in their places and fastened either by riveting or soldiering, as the case may require.

2. *The Key.*—Children will see that the key consists of one piece. Tell that it is brought into the required shape by forging.

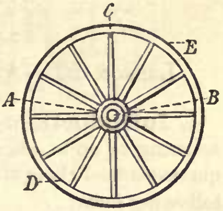
When of the required size and shape the webs of the *bit* or *wet* are marked out by pressing. If the shank is to be hollow it is now drilled or pierced, as it is called. The part of the shank so pierced is called the *barrel.* The *wards* or *webs* are now cut out by means of a chisel or file, when the key is ready for the finisher, who smoothes and polishes all parts so that it may work easily when put into the lock.

The chief seat of the manufacture of all ordinary locks and keys is in South Staffordshire, and principally in the neighbourhood of Wolverhampton.

LESSON 22.—A CARRIAGE WHEEL.

Provide a small wheel, and a picture of a large one.

I. Parts.—Let the children describe it as to form and parts. A wheel is a *circular frame*, which turns on a round bar called the *axle-tree*. The centre of the wheel is called the *nave* A; the part of the axle-tree on which the wheel turns is called the *arm*, and the part of the nave into which the arm passes is called the *box* B. In the nave there are a number of straight pieces of wood called *spokes* C, these are all of equal length, and stand out from the nave like rays.



Each spoke fits into the *rim* D, which is composed of a number of pieces of wood called *felloes*. All parts of the wheel are held together by a circular band of iron called the *tire* E. The tire is in one piece, and so is the nave.

II. Use of the Parts.—Question on the use of each part, and thus bring out that each part has its own use. Thus the box receives the arm of the axle-tree, upon which the wheel turns; the spokes keep the rim in its circular form, and unite the nave with the rim: the tire binds the felloes tightly together, and so keeps all other parts in their proper places; it also gives strength to the wheel.

The wheel is kept from falling off the axle-tree by a piece of iron called the *linch-pin*, which is put through a hole in the arm of the axle. Sometimes a screw is used instead of a linch-pin; when this is the case, the arm of the axle has what is called *a worm at the end*, and in this the screw acts. The arm of the axle is very smooth, and is always kept covered with oil or grease.

III. Different Kinds of Wheels.—Question out the fact that wheels are not all of the same size—some are very small, and some are very large: the large wheels have long spokes; the small ones have short spokes. Some wheels have very narrow rims; others have very broad rims; the wheels of wagons in which heavy loads are placed have very broad rims.

Some wheels are entirely formed of iron; the wheels of a railway engine are of this kind, and so are some of the wheels of railway carriages, and the wheels of bicycles and tricycles. All kinds of vehicles have not the same number of wheels. A wheel-barrow has but one; a truck has two, and so have hansom cabs, some kinds of carts, and other carriages, such as a gig, and a dog cart.

A wagon, a van, an omnibus, a tram-car, some cabs, and carriages, as a brougham, have each four wheels. Some railway carriages have six wheels, and some even eight. So have also railway engines.

The man who makes wheels is called a *wheelwright.* The wheels of carriages are beautifully painted and varnished; they are painted by a man who paints carriages; he is called a *coach-painter.*

LESSON 23.—A STREET IN A LARGE TOWN.

I. Introduction.—When the children leave their homes in the morning to go to school they have to walk through the *streets.* By questions lead them to describe what they saw, and so bring out the following facts:

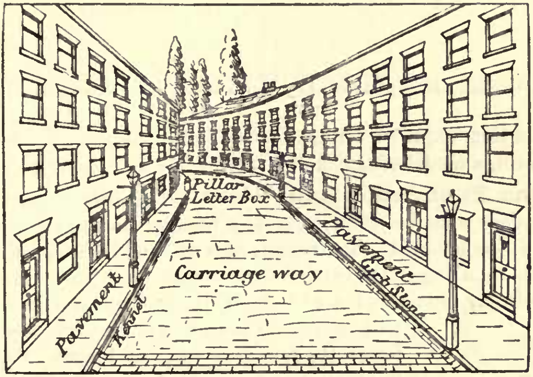
II. The Parts of a Street.—On each side of the street there is a *row of houses*, the front walls of which face the street on either side. That part of the street along which the people walk is called the *footpath.* In the street there are two footpaths, one on each side, and they are next to the houses.

The footpath is made of broad, flat, smooth stones: each stone is called a *flagstone;* they are placed close together, and are fastened to each other with mortar. The footpath is very smooth and even; this makes it pleasant to walk on, and as the stone is very hard it lasts a long time. Next to the flags are the *curbstones;* these are long and narrow, and thicker than the flagstones. The flagstones and the curbstones together form what is called the *pavement.*

Next to the pavement is the *kennel* or *gutter.* The kennel is a hollow place, a little lower than the pavement, and formed of small, square, rough stones. The pavement slopes slightly towards the kennel, so that when it rains the water may run off into the gutter. The gutter slopes toward the ends of the street, and there are openings made into the sewers, so that when the rain water runs along the gutter it goes down the openings into the sewers.

At certain distances along the curbstones are placed the *lamp-posts;* these are to hold lamps in which gas is burned when it is dark. Without these lights people would not be able to see to walk after daylight had gone.

Beyond the gutter is the *carriage way;* this is paved with small, thick, rough stones, which are fastened together with very thin mortar. The carriage way is a little higher in the middle than at the sides, and so it slopes to the kennel on each side. When it rains the water runs off the roadway into the gutter, and so keeps the carriage way drier than it would be if it were quite flat. The carriage ways of some streets are paved with wood and some with asphalte.



At the ends of the street are the *crossings;* these are paved with the same kind of stones as the carriage way, but they are laid very evenly and close together, so as to make them smooth and more pleasant to the feet when we have to walk across.

On the wall of the corner house of the street, at each end, is painted in large letters the *name of the street. Every house* in a street is *numbered;* the first house is called number one, the second number two, and so on. In some streets all the even numbers are on one side, and all the odd numbers on the other. When this is the case the first house on one side is number one, the second number three, and so on; and on the other side the first house is number two, the second number four, and so on.

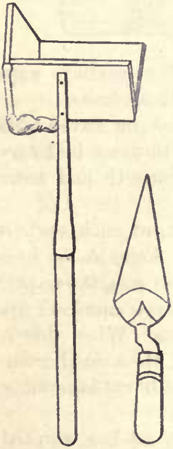
At the corner of some streets there is a large round box, painted red. In this box people put letters which they wish to send to their friends. This box is called the *pillar letter-box.* On it is painted the times of the day at which the letters are taken out of the box by the letter-carrier, or postman as he is called. The postman takes the letters to the post-office, where they are sorted, all which are for one part of London being put together; they are then taken to those parts and delivered at the houses to which they are addressed.

III. Moral Lesson.—When children are sent to walk in the streets they should always walk on the pavement; it is dangerous to walk or play either in the gutters or in the carriage way. They should also be careful not to throw orange peel or any other waste material on the pavement.

Lesson 24.—THE BUILDING OF A HOUSE.

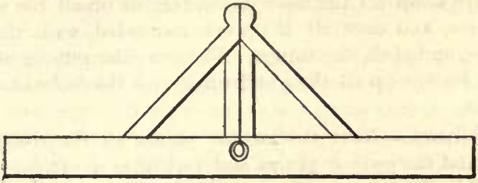
The objects required for this lesson are, a picture of a house, or, better still, a model of one, and a picture of a bricklayer at work.

I. The Foundation and Walls.—The first thing which a builder does when he wants to build a house, is to mark the size and shape of the house on the ground; this is called *setting it out.* A trench is then dug in the earth for the foundation. In these trenches the *bricklayer* puts a mixture of small stones, sand, and lime, mixed with water. This mixture is called *concrete*, and forms the *foundation* of the house. When this mixture gets hard the four walls of the house are built on it by the bricklayer, who puts a layer of thick mortar on the concrete, and on this he places a row of bricks, and on these a layer of mortar, and then another row of bricks, and so on until the walls are of the proper height. The mortar is laid on and spread with a tool called a *trowel.* The lowest part of the wall, or *footing*, is thicker than the wall above. In order that the walls may be perfectly upright the bricklayer every now and then places on the brick-work an instrument called a *level.* In the centre of the upright bar there is the *plumb line*, which consists of a string with a ball of lead suspended. If the wall is perfectly level, the ball hangs exactly in the centre of the hole in the bottom bar of the frame. As the walls increase in height a *scaffold* is made, and on this the men who are building the walls stand. The bricks and mortar are brought to the bricklayer by a labourer in a thing called a *hod.* Sometimes the materials are raised in a basket.



Hod. *Trowel.*

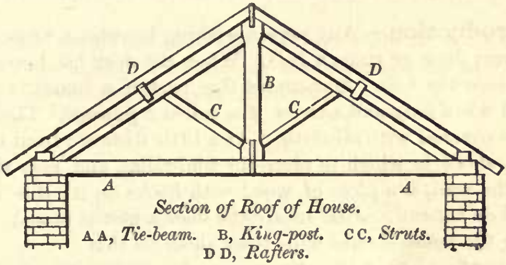
II. The Rooms.—In one of the side walls, or in both, the *chimneys* are formed, and in the front and back walls spaces are left for the doors and windows. The different rooms of the house are separated from each other by walls, and in these spaces are left for the doors of the rooms.



Level with Plumb Line.

When the walls are raised high enough to form a room, pieces of wood called *joists* are placed across and are fixed in the walls. On these joists are nailed the *laths*, which will be needed when the ceiling of that room is made. On these joists are also nailed the planks or boards which form the floor of the room above.

III. The Roof.—When all the rooms are made the *roof* is put on: this is covered with *slates*, which are put on by the *slater*, and are secured to the wood-work which covers the rafters. The chimneys are built higher than the roof: they are placed side by side, and are called a *stack:* a *chimney-pot* is put to each chimney.



Section of Roof of House.
A A, *Tie-beam.* B, *King-post.* C C, *Struts.*
D D, *Rafters.*

The door-steps, window-sills, and other parts made of stone are formed and put up by the *stone-mason.*

IV. The Work of the Carpenter, Plumber, Gas-fitter, &c.—The bricklayer having finished his work, the *carpenters* and *joiners* commence theirs. These men put up the stairs, nail down the floors, put in the window-frames, and put up the doors, and, indeed, do all the wood-work in the house.

While all this is going on the walls are covered with *plaster* by a man called a *plasterer:* this man plasters the ceilings also.

While these men are at work the *plumber* covers the flat parts of the roof with *zinc,* and he lines the cistern with the same metal. He also lays down all the *water-pipes,* fastens up all the water-taps in the house, and does all the work connected with the gutters, water-traps, and such like things. The *gas-fitter* puts in all the gas-pipes, and fastens up all the gas-fittings, and the *bell-hanger* puts in all the bells.

V. Finishers.—Next the *painter* paints all the wood-work in the house, and the *grainer* grains and varnishes the street doors, and sometimes all the doors in the house, also the sashes and frames of the windows. When the plaster on the walls is quite dry, the *paper-hanger* covers them with pretty ornamental paper. When all these various kinds of work are ended, the house is said to be finished, and after a sufficient time has been allowed for the paint to dry, and the varnish to get hard, the house is fit to be inhabited.

LESSON 25.—THE ROOMS OF A DWELLING-HOUSE.

I. Introduction.—Any person wishing to enter a house knocks at the street door, or rings a bell. When the door has been opened he steps into the *hall.* Sometimes this part of a house is called a *lobby,* and when long and narrow it is called a *passage.* The floor of the hall is covered with oil-cloth. At a little distance from the door there is a *stand* in which to place the umbrellas, and near this, fastened to the wall, is a piece of wood with hooks on it; this is called a *hat-rack* or *hat-rail.* Just inside the door a mat is placed. Those who enter the house should wipe their shoes on this.

II. The Names of the Rooms.—In the hall are doors which open into rooms called the *parlours,* the one in the front of the house is called the front parlour, the one at the back of the house the back parlour. In some houses these two rooms are separated by a wall, in others by a pair of large doors, which can be opened and doubled back so as to make the two rooms into one. These large doors are called *folding-doors.*

These rooms are used for the family to sit in when they want to rest, or work, or read. A nice soft carpet is placed on the floor, the chairs and sofa have soft cushions, and the table is covered with a pretty table-cloth. Pictures are hung on the walls, and ornaments are placed on the mantel-shelf. Some families take their meals in one of the parlours.

The STAIRS, by which people get to the different sets of rooms above or below the parlours, communicate with the hall; at different parts of the stairs is a flat place called the *landing;* the stairs between each landing are called a *flight.*

The flight of stairs that leads to the lowest rooms of the house is called the *kitchen stairs.* The whole of this part of the house is called the *basement,* and the rooms have various names, according to the use to which they are put. Thus the room in which the cooking is done is called the *kitchen,* that in which the family have their meals the *breakfast parlour,* that in which the food is kept the *pantry,* and that in which the washing and other dirty work is done the *scullery.* In this room there is a water tap, a sink, and a copper.

The other stairs in the hall lead to the upper floors of the house; that just above the parlours is called the first floor, the front room of which is sometimes called the *drawing-room,* and which has the best kind of furniture and ornaments. The back room on this floor is often used as a *bed-room.* In this case the furniture consists of a bedstead, a toilet or dressing table on which is placed a looking-glass, a chest of drawers, and a basin-stand. On the floor are strips of carpet.

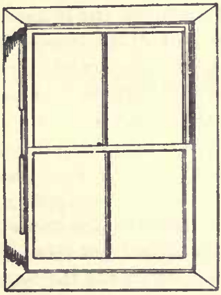
The rooms above the first floor are generally all *bed-rooms,* and have the same kind of furniture as the other bed-rooms. The top rooms of a house are sometimes called *attics.*

LESSON 26.—A WINDOW.

In giving this lesson the children are to be led to observe one of the school-room windows, and pictures of different kinds of windows should be shown to them.

I. The Parts of a Window.—Direct attention to the window, and by questions work out the following:—The window is made of wood and glass. The wood-work, which is placed on all four sides of the opening in the wall, is called the *frame.* The window itself is made in two pieces called *sashes*—the upper and lower sash. Each sash has a frame and spaces for the glass: each piece of glass is called a *pane.* The glass is fastened into the wood-work with *putty.*

To each side of each sash is attached a cord called the *sash line,* which runs over a little wheel, which cannot be seen because it is placed inside the top of the window frame. The end passes down a hollow behind the frame. At the end of the cord is a weight, which is just heavy enough to balance the sash, and so the sash can be opened as much as is needed, and it will remain where it has been placed until shut. If the sash lines are broken the windows cannot be opened easily, and when opened the sashes will not remain open.



A Window showing Sash Lines and Weights.

II. Qualities of the Materials.—The glass is transparent, and thus lets the light into the room, and enables us to see what is going on outside. It will not let the wind or the rain pass through, and so keeps out the weather. It is bright and smooth, and can be cleaned easily. It is hard and durable, but very brittle.

The wood-work of the window is not so hard as the glass nor so brittle; it is smooth, durable, and painted.

III. Kinds, and how Fastened.—Windows are of different sizes and kinds, and the number of panes in the sashes varies. Shop windows are much larger than house windows, and the panes of glass are also much larger. Some shop windows have only one large sash, which cannot be opened.

To prevent windows from being opened on the outside the sashes can be fastened together by a clasp, a part of which is placed in the middle of the lower bar of the upper sash, and the other part on the middle of the upper bar of the lower sash.

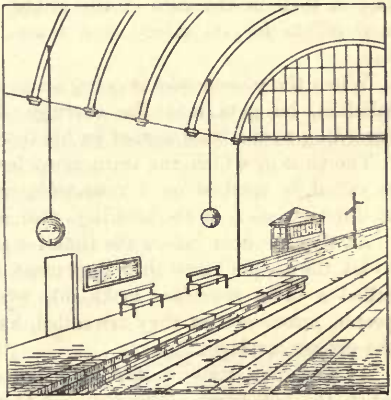
The man who makes the wood-work of the windows is called a *joiner*, and the man who cuts the glass into the proper size for the pane and fastens it into the sash is called a *glazier*.

IV. Moral Lesson.—When children are sitting at a window they should be careful not to press their hands on the panes of glass, as if they do they may break the glass and cut their hands; and when they are in the streets they should never throw stones at the windows, for if they do they may break the glass, and the people who keep the house will have to pay money to the glazier to put another pane in the window frame.

Lesson 27.—A RAILWAY-STATION, TRAIN, AND THE LINE.

The objects required for this lesson are, pictures of the outside and inside of a railway-station, with the train standing at the platform.

I. The Station.—When a person has to travel from one part of the country to another, he has to go by the *railroad.* The place from which the person starts is called the *station.* Before the journey can be commenced, the person who wishes to travel must go to the *booking office* and buy a *ticket,* either a first, a second, or a third class as he pleases. If, however, he wishes to travel by the Midland Railway, he must take either a first or third class ticket, as there are no second-class carriages run by that company. When the person has bought his ticket he is said to have "paid his fare." First-class tickets cost more money than second-class, and second-class more than third. Having obtained his ticket the person next goes on the *platform,* where the train is standing. The train is made up of an *engine* and a number of *carriages,* some first-class, some second-class, and some third-class. The ordinary fare for first class is 2½*d.* per mile, second class 1¾*d.*, third class 1*d.* to 1½*d.*



A Railway Station.

All the carriages are fastened together by iron chains called *coupling-irons.* The engine is fastened to a carriage called the *tender.* Round the sides of the tender there is a place to hold the water for the boiler of the engine, and in the middle of it there is a large place to hold the coals for the engine fire. The tender is fastened to the train by very strong coupling-irons.

II. The Train.—The engine and tender are under the care of a man called a *driver,* who has an assistant called the *fireman.*

This name is given to him because his principal work is to look after the fire of the engine.

The train is under the care of two men called the *guards*, who sit by themselves in carriages called the *brakes*, one of which is placed at each end of the train: these men are responsible for the train while running.

The parcels or boxes belonging to the person who is going to travel are called his *luggage*. On each box or parcel a piece of paper is pasted, on which is printed the name of the railway, and the name of the place to which the owner has taken his ticket. The piece of paper is called a *label;* it is pasted on the box by a *porter*, who, when he has done this, is said to have labelled the luggage. When this has been done, the luggage is put into the luggage van, and is then in the care of the guard, and the railway company is responsible for its safety, and must make it good if injured or lost.

When the person who is going on a journey has seen his luggage labelled, he gets into the carriage, first, second, or third class, according to the class named on his ticket.

The time at which the train is to leave the station, or *start* as it is called, is marked on a *time-table*, copies of which are hung up in different parts of the booking office, and on the platform.

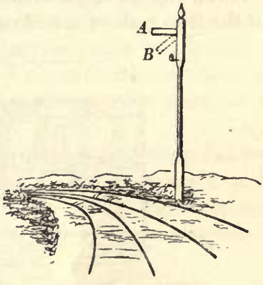
At five minutes before the time for starting a porter rings a bell to let the people know that they must take their seats: then a man called a *ticket examiner* looks into every carriage to see that the people, *passengers* as they are called, have their tickets, and are in the proper carriages.

At the exact time of starting a porter rings the bell again, and when the people are all seated and the carriage doors fastened, the *station-master* gives a signal to the guard that all is right; the guard then blows a whistle to let the engine-driver know that all is ready for starting. As soon as the driver hears the guard's whistle he sounds the steam-whistle of the engine, turns on the steam, and then with a loud puff, puff, puff, the train commences its journey.

III. The Line.—The train runs upon a pair of wrought-iron or steel *rails*, which rest in what are called *chairs* made of cast-iron; these chairs are securely fixed to pieces of wood called *sleepers*, laid about 3 feet apart. The ends of the rails are held down by a plate of malleable iron placed on each side, called a *fish-plate;* two of these are used at each joint, and are bolted together by strong bolts passing through the rails. The rails are of varying thickness, and are laid in pieces about 24 feet long. It will be observed that their ends are not brought into close contact, a space being allowed for alternations of length due to change of temperature.

If the train is travelling from London, it is said to be going on the *down* line; if travelling towards London, then it is said to be on the *up* line. The lines of rail are spoken of as either *main* or *branch*, according to whether they lead direct from London, or any other great town, to another great town, or to some smaller place on the right or left hand side. The place where the train leaves the main line to travel on the branch is called the *junction*. The same name is given to the spot where one main line joins another. When, as is sometimes the case, one line crosses another at the same level, the place is called a *crossing*.

The driver of an engine does not stop and start his train just when he pleases; these points are ruled by *signals*. These signals consist of an upright post with a movable arm as shown in the picture. When the arm is placed as at A, it is a signal of danger, and the engine-driver is bound to stop the train; when the arm is placed as at B, it is a sign that the line is clear, and the driver is to proceed. At night a lamp is used, and by means of coloured glasses brought in front the same things are indicated; a *red light* signifying danger, or line blocked, and a *green* one signifying "all right," or line clear. When there are no other lights visible, then a *white* light is used for "all right," and a *green* one for "caution." But in and around London only red and green are used. These signals are worked by a man in a box, and for the right working of which he is responsible. All the signal boxes are brought into communication with each other by a *telegraph*, and on many railways no train is allowed to pass one station or box until the previous train has passed the next box or station, and so of course the line between the two is clear. When this is the case the *block system* is said to be in use.



Railway Signal.

Many very dreadful accidents have happened to trains through the signals not being properly worked or neglected.

There are now numerous railway companies throughout the country. Among these the following are the principal English companies: the Great Northern, the London and North-Western, the

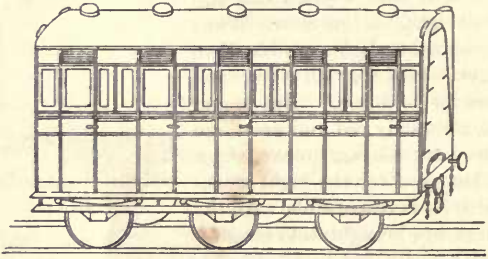
Midland, the Great Western, the South-Western, the Great Eastern, the South-Eastern, the Brighton and South Coast, the London, Chatham, and Dover, the Cambrian, the Lancashire and Yorkshire, and the North-Eastern. In Scotland, the Caledonian, North British, Glasgow and South-Western, Great North of Scotland, and the Highland are the chief; and in Ireland the Great Northern, Great Southern and Western, and the Midland Great Western.

At the end of 1890 there were 20,073 miles open for traffic in the United Kingdom. The total capital of the companies was £897,472,026. The number of passengers conveyed, exclusive of season-ticket holders, was 817,744,046.

LESSON 28.—A RAILWAY-CARRIAGE.

I. Introduction.—Let this lesson follow that on the RAILWAY-STATION. Recapitulate the chief points, and tell subject of this lesson. Let children examine the picture of a third-class railway-carriage. Mention all the parts known. Direct attention to the others, and work out the following matter:—

A railway-carriage, as its name implies, is a carriage made to run on the iron rails of a railroad. The one to be described is a third-class carriage of the Great Northern Railway Company. Children must go to the station to see a real carriage, now they can only look at a picture of one.



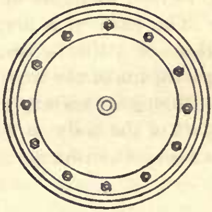
A Railway-carriage—Third-class of Great Northern Railway.

II. Parts, and Uses of the Parts.—The whole carriage consists of two distinct parts: the top part called the *body*, and the under part called the *under-carriage.*

1. *The Under-carriage.*—The under-carriage consists of a strong frame made of four pieces of iron on the outside, and four pieces of thick wood on the inside; the wood is fastened to the iron by rivets.

The long pieces are called the sides of the carriage and the short pieces the ends. At the ends two iron knobs called *buffers* are fastened, and a strong iron hook, to which is hung the coupling-irons.

To the under-carriage are fastened the *axles* on which the wheels turn, and the *springs* on which the body rests. There are three axles, three pairs of wheels, one pair to each axle, and three pairs of springs, one pair for each pair of wheels.



A Railway-carriage Wheel.

The wheels are not like those of an ordinary carriage; they have no spokes, but the space between the *box* and the *tire* is filled up with wood, which is kept in its place by the tire. On one side of the tire there is a piece of iron called a *flange;* it is this which keeps the wheels from running off the rail when the train is in motion.

In front of the wheels, running the whole length of the under-carriage, are two long boards called the *foot-boards,* these are to enable the passengers to step up to the carriages when they are standing on a platform which is lower than the carriages.

2. *The Body.*—The part which rests on the under-carriage is called the *body,* which is fastened to the under-carriage with iron bolts and screws. The body is made of a great many pieces of wood all fastened together by screws, nails, and glue. The pieces which are used to make the ends and sides are called *panels.*

The body is divided into five compartments; each of these has two doors, one on each side facing each other. Each door has a glass window, which can be opened and shut by being drawn up and down; there are also two windows on each side of the compartment, one on each side of each door.

In each compartment there are two *seats,* one on each side of the doors, and on the seats there are *cushions.* There is a space between the seat and the floor of the carriage. This is very handy, as the passengers can put their little parcels under the seat. Above each seat is a *hat-rack.* It is not, however, like the hat-racks in the hall of a house, but consists of a rail of wood, to which is fastened a kind of net, and this net is fastened to the carriage. In this rack the passengers can place any small parcels which they have with them. In the roof of the carriage there are *lamps,* one in each compartment.

All the wood-work of the carriage is painted and varnished, and on the outside of the panels of some are the letters G. N. R. (Great Northern Railway), and the number of the carriage.

At the ends of the body there are *iron steps*, these are to enable the men who put in the lamps to climb on the roof. The following are the dimensions of one of the Great Northern Company's new third-class carriages:—Length of carriage from buffer to buffer, 34 feet; width, 7 feet 6 inches; height from rail to top of roof, 11 feet 6 inches; diameter of wheel, 3 feet 6 inches.

The parts of a first and a second class carriage are the same as those of a third-class; but they are differently fitted up. The compartments of the first-class carriage are wider than the third, and the cushions are softer; the seats are something like arm-chairs, and the part of the body on which a passenger leans his back is covered with a nice soft cushion.

SECTION II.—FOOD SUBSTANCES.

Lesson 29.—TEA.

Objects required, a small quantity of the several kinds of tea, a picture of the tea-plant, a tea-pot, and some boiling water.

I. Introduction.—Remind the children of the fact that they often hear their mothers say, "I want my tea very badly," and then when they have had a cup of good tea they said, "I am much refreshed now." When any one is tired and thirsty there is nothing better to drink than a cup of tea.

Tea Plant.

II. Qualities.—Show the different kinds of tea which are sold by the grocer. Some of these are black, others green. Put a little of each into some hot water, leave it for a short time, and then examine. Each thin curly piece of tea will be found open, showing that it is a leaf.

One or two to be laid on a sheet of paper and the class to describe them. The shape of the leaf is that of a long oval, very pointed at the ends. Such a leaf is said to be lance-shaped. The edges of the leaf are toothed like a saw—serrated. Compare the leaves: children will see that they are all alike in form, but differ in size; some are two inches long, others three, and some even five. Let the children examine the water in which the leaves were placed, and describe it. It is brown, and is what we call *tea.* The colour, odour, and flavour have been drawn out of the leaves by the hot water.

A larger quantity of tea now to be put into some hot water. The water is much darker than the other; it has more odour and more flavour. We may call this stronger tea than the other. Children will see that the larger the quantity put in the water the stronger will be the tea.

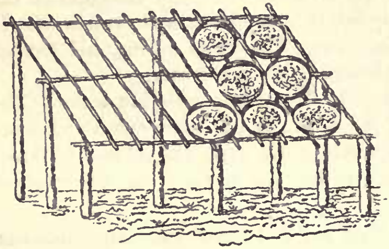
III. The Making of Tea as a Beverage.—Now question out, or tell if not known, how tea is prepared from the leaves. When tea is to be made for the meal the tea-pot is first warmed, then a certain quantity of tea is put into the pot, one, two, or three teaspoonfuls according to whether strong or weak tea is wanted. Next boiling water is poured on the tea and the pot kept warm. In a little while the tea is said to be drawn and is ready for use. Tea should never be boiled, but the water must be really boiling when it is put on the tea.

IV. The Tea-tree.—Show a picture of the tea shrub. Tell what cannot be found out. It does not grow to be a large tree. There are leaves on the shrub all the year, and so it is called an evergreen. When the leaves are growing on the shrub they are of a deep green colour and of different lengths. The flowers of the tea-shrub are very pretty; they are white with a number of yellow stamens in the middle. The flowers are not used.

The tea-plant will not grow in England; it is a native of China and Japan. Almost all the tea which is used is brought from China. The tea-shrub is now grown in some parts of India, especially in Assam.

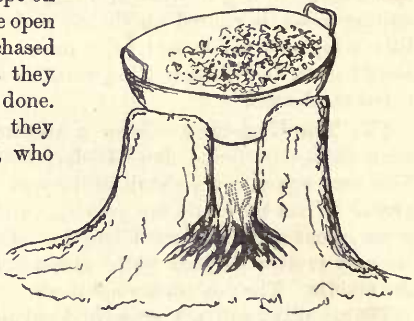
1. *The Picking of the Leaves.*—As only the leaves of the tree are used they have to be picked off the plant by hand. Show picture of a Chinese in his tea-garden, with men, women, and children all busily engaged.

The leaves are gathered from one to four times during the year, according to the age of the tree. Most commonly there are three periods of gathering: the first commencing about the middle of April, the second at midsummer, and the last during August and September. The leaves that are earliest gathered are of the most delicate colour and most aromatic flavour, and are those used for the finest kinds of teas. Leaves of the second gathering are of a dull green colour and have less flavour. Those last gathered are least valuable, and are those that are used for the common sorts of tea.



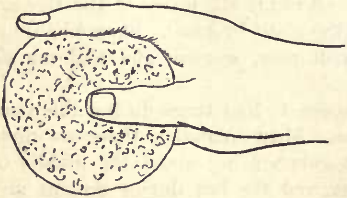
Sun Drying.

2. *The Preparation of the Leaves for the Market.*—The leaves, as soon as gathered, are put into wide shallow baskets and placed in the air, or wind, or sunshine during some hours. They are then placed in a cast-iron pan over a stone heated with charcoal, from a half to three-quarters of a pound being put on at one time. These leaves are stirred quickly about with a kind of brush and are quickly swept off the pan. By comparing the open leaves with the tea as purchased the children will see that they are all twisted. Tell how done. After the leaves are dried they are taken to the *twisters,* who take up some leaves and rub them between their hands. In the case of the finer sorts of tea each individual leaf is twisted or rolled into a ball. In some cases the rolling is effected by machinery.



Drying over Fire.

After the twisting the leaves are again dried in a pan heated over a charcoal fire. When perfectly dried the tea is sifted, the leaves are examined and the imperfect ones removed. This done the tea is packed in chests lined with very thin lead-foil and sold to the tea merchant, who sends it to England, and in turn sells it to the grocer or tea-dealer, who again sells it to those who want to use it. Each chest contains 80 lbs. of tea.



Rolling by Hand.

V. Different Kinds of Tea.—Refer the children to the various names which they may have heard in connection with tea, as Bohea, Souchong, Pekoe, Congou, Hyson, Gunpowder, &c. Tell that the leaves both for the black teas and green are plucked from the same trees; the difference lies in the preparation of the leaves. Those gathered earliest in the year and from the new wood producing the finest green teas. These leaves are gathered one at a time, more carefully dried, and twisted or rolled singly.

VI. The Quantities of Tea Consumed.—By calling attention to the fact that every family in England drinks tea once or twice every day, the children will realize that the quantity used must be very great, and so will be interested in the following facts. In the year 1891, 240,779,331 lbs. of tea were imported into this country. The declared value of the same was £10,733,140. Of the total amount imported 202,456,010 lbs. were consumed in the United Kingdom.

For each pound of tea consumed fourpence is paid as duty to the government. The revenue from this source in the year 1891 was £3,374,272.

In order to afford some idea of the labour of producing this amount of tea, tell the children that to manufacture 80 lbs. of black tea a day 25 tea-gatherers are requisite, and 10 driers and sorters. To produce 92 lbs. of green tea 30 gatherers and 16 driers and sorters are requisite.

Tea is always sold by weight. The price varies according to the quality, ranging from four shillings to one shilling and eightpence a pound.

Tea was first introduced into Europe by the Dutch East India Company; and about the year 1666 a small quantity was brought from Holland to England by the Lords Arlington and Ossory. At first it was sold for sixty shillings per lb.; and for many years its price limited its use to the rich. At the present day a pound of very fair tea can be purchased for two shillings or even less.

The London market value of teas in bond, *i.e.* before the duty is paid, ranges from 6*d.* for the commonest kinds to 4*s.* 6*d.* for the very best.

LESSON 30.—SUGAR.

The objects required for this lesson are, loaf and moist sugar, treacle, and a picture of the sugar-cane.

I. Introduction.—Although children know many of the uses to which sugar is put, and the reason why it is so used, they do not all know what sugar really is, nor how the different sorts are produced. This lesson is intended to teach them these things.

II. The Nature of Sugar.—Show picture, and question out that sugar is obtained from a plant, and is therefore called a *vegetable substance.* The particular plant from which it is obtained is called the *sugar-cane,* which is a very large kind of grass. It differs, however, from our grasses. First in its size: its height ranges from eight to twenty feet: its thickness being about two inches. Second, in the character of its stem: this is solid in every part, being filled with pith and a sweet sap. Third, in the nature of its flowers: the flower head is often more than two feet long, each flower is surrounded with long reddish coloured hairs, while the flower itself is of a pale rose-colour. It is a very elegant object. The sugar-cane will not grow in all parts of the world, nor yet in all hot countries. Its proper home seems to be, some parts of the East Indies, some of the West India Islands, and some of the South Sea Islands.

Sugar Cane.

III. How Sugar is obtained:

1. *Obtaining the Juice.*—Tell children that the sugar is not found in the plant in the state of moist sugar, but as a juice in the stem of the ripe cane. To obtain the sugar the ripe canes are cut down and removed from the field. Each cane is cut into pieces and crushed between large iron rollers. This crushing causes the juice to run out; as it flows it is caught in large pans which are placed under the rollers. This juice, however, is not like the sugar which is sold for our use: it has to be prepared.

2. *Getting the Sugar from the Juice.*—The juice is placed in large copper vessels and boiled until it becomes thick. When the boiling has been carried on long enough, the thickened liquor is poured into open pans and allowed to cool. While the cooling is going on almost all the thickened juice turns into small crystals: *it is now called sugar.*

When the sugar is quite cold it is placed in large casks called *hogsheads.* A number of small holes are made in the bottom of the casks, and through these any portion of the juice which will not crystallize runs out. *What does run out is called treacle.* The sugar in the casks is called *raw* or *moist sugar,* and is sent to England and other countries. On the table there are several kinds of this sort of sugar. They all differ both in form and colour from *loaf-sugar;* all the moist sugars are more or less of a yellowish-brown colour, and consist of separate grains, while the loaf-sugar is quite white, very sparkling, and in one piece. The loaf-sugar was made from the moist in the following way:

3. *Sugar Refining.*—A man called a sugar refiner took a quantity of raw sugar, dissolved it in warm water, mixing with the water a small portion of lime—such as builders use to make mortar with. This mixture was then poured into bags made of woollen cloth, and allowed to strain through, or filter as it is called. The portion which ran through the cloth was clear, but still brown, so not yet fit to be made into loaf-sugar, which is white. The colour was now taken out by filtering it again, but this time through a layer of charcoal, made by heating bones to redness in a close vessel. After the liquor had passed through this charcoal it was colourless, but still a liquid. This colourless liquor was next put into copper pans, so closely covered that no air could get in, and boiled. The boiling takes place with much less heat when the air is kept away than when not kept away. The steam which was formed as the liquor boiled was pumped out of the vessel, and of course the liquor gradually got thicker. When sufficiently boiled it was poured into moulds and allowed to cool gradually. As it cooled the pure sugar formed itself into small crystals which fastened themselves to each other. The portion of the liquor which would not crystallize ran out and was called *golden syrup.* The lump of sugar in the mould was now called a *loaf,* and was sold to the grocer, who chopped it into pieces and sold it to his customers as *lump-sugar.*

IV. Uses of Sugar.—Sugar is used for many other purposes besides sweetening tea and coffee, and other articles of food: it is boiled with currants, raspberries, and other kinds of fruit to make *jams.* It is also made into barley-sugar, sugar-candy, and other kinds of *sweets,* as they are called. The two former are the best for children to eat, as they are made entirely of pure sugar. A very large quantity of sugar is used in the manufacture of beer.

The quantity of sugar consumed in this country is immense. In the year 1891 the importation of this article reached the enormous amount of 4,973,372,992 lbs., the value being £30,815,651.

LESSON 31.—COFFEE.

The objects required for this lesson are, some ground coffee, a few coffee-berries, both roasted and unroasted, a picture of the coffee-tree, and some boiling water.

I. The Qualities of the Berries.—Introduce the lesson by telling its subject, and allowing the children to say what they know about coffee; namely, that it is bought from the grocer in the form of a powder, which is produced by grinding the roasted berries of the coffee-tree. Show both roasted and unroasted berries, and let the children say wherein they resemble each other, and in what points they differ, and so bring out that—

Both are oval, have two faces, one curved and one flat, the flat side is grooved. Both are solid, hard, and dull.

The points of difference are:

The unroasted berries are of a pale yellowish colour, very hard and tough; they have but little flavour and are nearly odourless.

The roasted berries are of a dark brown colour, hard, crisp, and have a strong aromatic flavour and odour.

II. The Character of the Coffee-tree.—Show picture of the coffee-tree and of the flowers and berries. Let the children describe, and so bring out the following facts. What cannot be discovered to be told.

Coffee Plant.

The tree grows to the height of twelve feet, slender, and at the upper part dividing into long trailing branches. The leaves are of a deep bright green, somewhat resembling those of the Portuguese laurel. The tree is an evergreen. Round the joints of the branches there are a number of white flowers, in form not unlike those of the jessamine. A great many of the flowers open at the same time, and as they grow on all parts of the branches, when the tree is in flower it looks as if it were covered with snow. The flowers do not remain in their beauty for more than two days.

Out of each flower grows a dark red berry, which when ripe is about the size of a cherry, and something like it in being fleshy. Each cherry-like berry contains two seeds (called *coffee-beans*), which stand with their flat sides together, and are held in their places by a thin tough skin called the *parchment*.

III. Gathering of the Berries and Preparing them for Market.—When the berries are quite ripe they can be easily shaken from the tree. Before they are shaken from the tree cloths are spread on the ground, and these keep the soft berries from getting dirty. The berries are gathered up and placed in the sun to dry. When dry the soft covering is removed and the seeds are again placed in the sun to dry. The next thing to be done is to remove the tough skin, or parchment, which covers the two seeds. This is done by putting them into a trough in which there are some rollers; when these are moved they press tightly on the seeds and so break the skin into small pieces, which are afterwards blown away by a machine called a winnow.

The coffee-seeds are next put into bags, and sold to the merchant, who brings them to this country, and sells them to the grocer, who roasts them in a closed iron vessel, something like a small barrel in shape. This vessel, which is called a *coffee roaster*, is kept turning round and round over a gentle fire. After the coffee has been roasted it is ground in a *mill*, and then sold to those persons who want to use it. Coffee is always sold by weight, at a certain price for a pound; the very best kind costs one shilling and eightpence a pound; the commoner sorts cost less. Some can be bought for one shilling a pound. Sometimes a vegetable substance called *chicory* is mixed with the coffee. When this is the case it is sold as *a mixture*, and not as pure coffee. Some people prefer this mixture to the pure substance.

At the present day the essence of coffee is sold in bottles; and when any person wants a cup of coffee for drink, a small quantity of the essence is put into some boiling water, and a cup of coffee is at once ready for use.

IV. Preparing Coffee for a Beverage.—Coffee is prepared for use by being put into a coffee-pot, and boiling water being poured upon it. After a few minutes the coffee is ready to be poured into the cup, sugar and milk are added to make it taste sweet and nice.

During the year 1891, 83,682,197 lbs. of coffee were imported, the value being £3,445,000. The quantity consumed in the United Kingdom was 29,245,274 lbs. Raw coffee pays a duty of 14*s.* per cwt. and roasted coffee 2*d.* per lb. Coffee has been drunk as a beverage in this country for more than two hundred years. The first coffee-house was opened in England in the year 1652: it was situated in George Yard, Lombard Street, London. In 1660 the keepers of coffee-houses had to pay fourpence duty for every gallon sold; and in 1663 they had to pay a license for their shops.

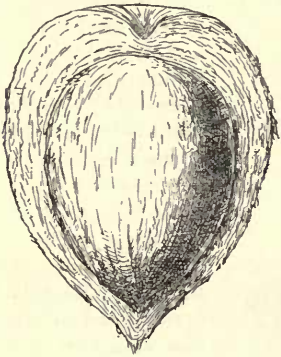
LESSONS 32 AND 33.—THE COCOA-NUT AND THE CACAO-NUT.

These two lessons are written in the style in which they would be given. The teacher is supposed to be addressing the children. The objects required for the lessons are, some cacao-nuts, flaked and soluble cacao, a cocoa-nut, and pictures of the trees from which both kinds are obtained.

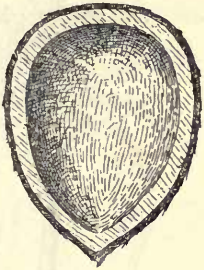
First—THE COCOA OR COKER NUT.

I. Introduction.—Two boys were talking to each other about what they each had bought with some money which had been given them on the last bank holiday. One boy said he had bought a penny *slice of cocoa-nut*, the other said he had bought a *penny cup of cocoa.* Now both these boys thought that the cocoa-nut which was bought in slices was the same as that used to make the beverage cocoa which is drunk at meals. But they were wrong, and the class shall be taught why they were wrong.

II. Qualities of the Coker and Cacao Nuts.—Here is a cocoa-nut, such a one as that from which the slice bought by the boy was cut: and here is one of the cocoa-nuts, such as were used to make the cocoa which the other boy drank. They are very different in *size* and *appearance;* the cocoa-nut which is sold in slices is very much larger than the other. The small nut should be called the *cacao-nut*, not the *cocoa.* They grow upon very different kinds of trees. Here are pictures of each. The *cocoa*, or as it is generally called the *coker* nut tree is a *palm*, which is, you see, a very tall slender tree without any branches, and having all the leaves at the top. The stem often attains to the height of one hundred feet or more. The leaves, of which there are about fifteen, are from twelve to fourteen feet long, composed of a double row of sword-shaped leaflets, in length from three to four feet. Each leaf resembles a gigantic ostrich feather. The *cacao* tree is not a palm, but a tree something like the English cherry-tree. Both trees grow in foreign countries. But the two nuts differ from each other in several other ways besides their size and the kind of tree on which they grow. You shall now learn all you can about each: and first as to the *cocoa-nut.* Here is one just as it was taken from the tree on which it grew. The nut, you see, is inclosed in an outer *husk,* which has three flat sides, terminating at the top in a blunt point. The outside of this husk is smooth and the inside fibrous. The nut with the covering is as large as a man's head.



Nut in the Case.



Section of the Nut.

Here is a nut which has been taken out of the husk. You see that it is oval, and of a light brown colour. The *shell* is rough on the outside, very hard, and difficult to break. Here is another nut which has just been broken. The white part which comes next to the shell is called the *kernel:* this is the part which is eaten. The kernel is white on all parts except that which comes next to the shell, where it is brown. The kernel is hollow in the centre, the hollow is filled with a *sweet milky liquid.*

III. Uses of the Tree and Nut.—Most children know of only one use of the cocoa-nut, and that is to eat; but both the nut and the husk are used for several other purposes.

1. *Uses to the Natives.*—It will interest you all to know the many uses to which the nut, and the parts of the tree on which it grows, are put by the natives of the countries where the tree is found. If you lived in a place called Ceylon you would see a native build his hut with the trunk of the tree, and thatch it with the leaves: from

the wood, when sawn into planks, he makes the door, windows, bolts, and bars, also his chairs and tables. The leaves are made into baskets, pails, and writing-books. Then, again, the man will make his canoe out of the trunk, and the oars out of the midribs of the leaves. From the smaller ribs he makes torches to give him light at night, and brooms to sweep his hut with. From these ribs he also makes his arrows to shoot with, and his pens to write with. The fibrous covering of the nut, called *coir fibre*, is twisted into cords, and then formed into fishing-nets and into hammocks; and from a fibrous substance formed at the base of the leaves a coarse cloth is made called *gunny cloth* or *goni*, and sacks made of this cloth are called *gunny bags* by the English. The kernel of the nut supplies him with food, and the juice he uses as milk to drink, and to put into his coffee. From the ripe kernel he gets oil to burn in his lamp and to rub on his hair. The shell he makes into lamps, cups, jars, spoons, and musical instruments. When the tree is growing the man will get the juice out of the flower, which he either drinks or boils to get the sugar which is in it, and from this sugar he makes a strong drink called *toddy*, or, if he pleases, *vinegar*. The leaves are also used as food for tame elephants.

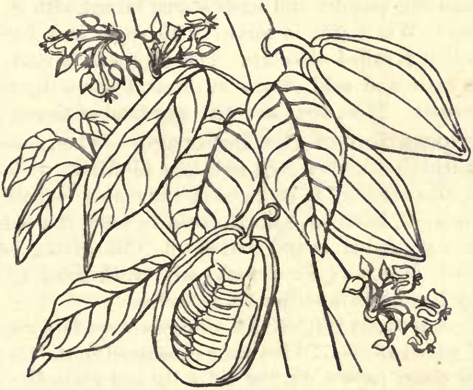
The Coker-nut Palm, with Flowers and Fruit.

2. *Uses in this Country.*—In this country the nut is only eaten as a nut, but many thousands are brought here for the sake of the oil which is pressed out of them. At the ordinary temperature in this country the oil is seen in the form of a solid lump of fat. It is used in making some kinds of candles. (See lesson on CANDLES.)

The strong fibres of the husk are also used for many purposes. They are twisted into a coarse thread, and this is woven into matting for floors, or made into door-mats. The loose fibres are used for several purposes; the very coarse ones are made into scrubbing-brushes and brooms, and the finer ones are often used as a stuffing for mattresses. You see now that the cocoa or coker nut, and its tree are very useful things; and next time you buy a slice of the nut you must try to remember some of the things which you have learnt at this lesson.

Second—THE CACAO AND THE CACAO-NUT.

I. Description of the Tree.—You must now learn something about the other cocoa or *cacao*-nut, which was used to make the cup of cocoa which the boy bought with his penny. Here is a picture of the tree on which these nuts grow. In size and in the shape of the leaves it is something like an English cherry-tree. But then it is an evergreen tree, which the cherry is not, and the fruit is very different. The cherry, you know, is a small round fruit, and the seed, or stone as it is called, is covered with a soft juicy flesh; each cherry has but one seed.



The Cocoa-Tree, with Pod and Flowers.

Here is a picture of the fruit of the cacao-tree. You see that it is a large *pod* between eight and nine inches long and about four inches broad. It is woody and tough. Here is a picture of the inside of the pod; you see that it is filled with a pinkish white substance, which is called *pulp*, and inside this there are the *seeds*, or *nuts* as they are called. These seeds are packed closely together, and they all stand on a centre core.

Each nut is about the size of a small bean, with a thin, dark brown, brittle shell, covering a kernel which is of the same colour as the shell. In the kernel there is some oil, which will run out if the nut is pressed with a heavy weight.

II. Preparation of the Nut.—These nuts are not eaten raw, but are used to make the beverage which is called *cocoa*, and also to make *chocolate*. To make the nuts fit for these uses they are roasted in the same manner as the coffee-seeds are. (See lesson on COFFEE.) The next thing done is to take off the outer skin, and then the kernels are ground.

When the kernels are only broken into small pieces they are called *nibs*. When they are formed into thin slices it is called *flaked cocoa*. When all the oil is pressed out of the nuts, and then these are ground into a fine powder and some starch mixed with it, it is called *soluble cocoa*. When this is mixed with sugar and formed into a kind of paste it is called *chocolate*. This chocolate is made into small sticks and balls, and sold at the sweetmeat shops by the name of *chocolate creams*. Most boys and girls are fond of these.

III. Preparation of the Beverage.—When cocoa is boiled with water it makes a very good beverage to drink. It is very nourishing. If nibs are used to make cocoa they must be boiled in water for some time; if, however, soluble cocoa be used it need only have boiling water poured on it and stirred up. Cocoa is a good beverage for breakfast, especially for persons who work hard all day; it is more strengthening than either tea or coffee.

In the year 1891, 34,030,981 lbs. of cocoa were imported into this country, of which 23,856,776 lbs. were consumed in the United Kingdom. Raw cocoa pays a duty of 1*d.* a lb. and manufactured cocoa 2*d.* a lb.

LESSON 34.—BREAD AND BREAD-MAKING.

The objects required for this lesson are, several kinds of loaves and the materials for bread-making.

I. Introduction.—When children return home from school or from play they are hungry, and ask their mothers for food. What does she give them? Some bread. How did she get the piece? Cut it off a loaf. The lesson will be on a loaf of bread, and how it was made.

II. The Parts of a Loaf, and the Qualities of each.—Children to name the several loaves on the table—quartern, half-quartern, cottage, coburgh, &c. Then examine the quartern, and name its parts and their qualities—top, bottom, sides. The top and bottom are hard, brittle, and brown. This part called the *crust:* it is sweet to the taste. The sides are soft and white. This part called the *crumb.* Compare crumb with crust as to qualities. Colour yellowish white; full of little holes—pores, so said to be *porous.* Can be pressed into smaller space, is *compressible.* When bread is very easily so pressed it is said to be *spongy.*

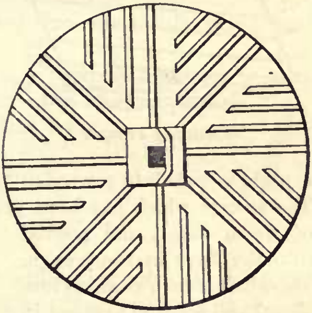
Pour a small quantity of water on the crumb. Call attention to what takes place. The bread has taken the water into itself. Because of this said to be *absorbent.* Question as to when they eat bread. At most meals. What takes place to their bodies day by day. They grow. The bread helps to do this, and because it does so is said to be wholesome and nourishing.

III. Bread-making:

1. Materials of a Loaf.—Show these. Flour, water, yeast, and salt.

Question as to what flour is. Show some wheat, and compare:

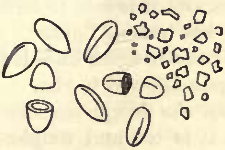
a. Wheat first ground.—Wheat a hard brown grain; flour a white powder, soft to the touch and adheres slightly to fingers. Crush a grain of wheat, when children will see that the flour is obtained from central portion. Explain and illustrate how the wheat is ground, between two flat stones. Some whole meal compared with the white flour.



Mill Stone.

b. Then sifted.—Children will see that the husks have been taken out. Let them suggest how this may be done. Tell the exact mode.

Grains of Wheat.

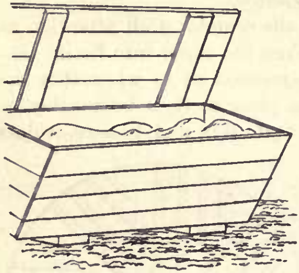


Bran and Flour.

The meal passed through very fine sieves called *silks,* by which the husks or *bran* is separated from the fine flour. The finer the "silk" the finer the flour. This process is called *dressing.*

2. Making of a Loaf.—Compare separate materials with the bread. What must be done with them? Tell how this is done.

a. Setting the Sponge.—A certain quantity of flour, say a quarter of a pound, is put into a pint and a half or so of lukewarm water and thoroughly mixed. To this is added about two table-spoonfuls of yeast. This mixture, which is of the consistence of thin batter, is set aside in a warm place for six or eight hours to ferment; at the end of this time the mixture will have risen considerably and will resemble in appearance the yeast. This mixture is called the *sponge.*

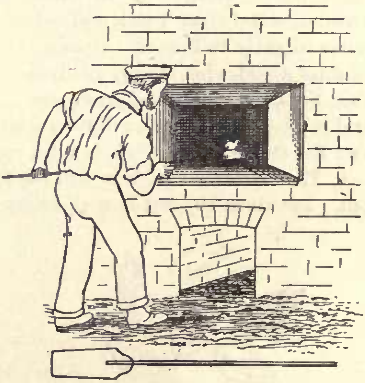


Kneading Trough.

b. Kneading the Dough.—By comparing this sponge with the bread, children will see that it is too thin to make bread. Let them suggest what must be done. Mixed with flour. Tell how this is managed. A certain quantity of flour, say half a peck, is put into a wooden trough with a small quantity of salt. The sponge which has been previously made is mixed with a pint of warm water, and poured into the flour in the trough. The whole is then kneaded into *dough* and allowed to stand in a warm place for several hours. In a short time the sponge begins to act upon the whole mass, fermentation takes place, the dough becomes inflated with innumerable air cavities, and it is said to have risen—has become light.

The mass is again kneaded, and again allowed to rise.

When the dough has risen again, it is cut and weighed out into lumps of the proper size, which are then shaped into loaves; the whole number of loaves made at the same time is called a *batch.*



Baking Oven, and Peel.

After standing for a short time the batch is put into the oven and baked. When the bread is sufficiently baked it is taken out of the oven, this is called *drawing the batch.* The loaves are put into the oven and withdrawn with an instrument called a *peel.* The loaves are placed on shelves to cool, ready for the customers.

IV. Different Kinds of Bread.—Let the children mention the kinds of bread which they may have seen, as:

White Bread, such as that on which the lesson has been given.

Brown Bread, which is made with flour containing some of the outer covering of the wheat.

Whole-meal Bread, which is made of the pure meal obtained by grinding the wheat.

Aerated Bread, both white and brown. This kind of bread is made without yeast, carbonic acid gas being used instead.

Milk Bread, which is made of very fine flour, milk being used with the water in mixing.

Whole-meal bread is more nourishing than white, but it is more irritating to the stomach, and does not agree with all persons.

New bread is not so digestible as stale bread.

LESSON 35.—MILK.

I. Qualities of Milk.—Place a glassful of milk on the table, and let the children name its qualities. Thus work out that *milk is a white, opaque liquid, sweet to the taste and soft to the touch.*

Provide two pieces of clean calico. On one pour some milk, on the other some water. Dry both. Call attention to the state of each. The piece on which the milk was poured is stained, the other is not stained. The stain left by the milk was caused by the grease which it contains. So milk is greasy.

Elicit the fact that most people can drink milk at any time of the day, and children, when they are very young, have no other food, and yet they grow and become strong. They will thus see that milk is both wholesome and nourishing.

Question (1) as to the source of the milk we drink: a cow. So *milk is an animal substance.* (2) How people in London and other large towns get the milk which they need. Certain persons keep cows for the sake of the milk these animals give; and their cows supply them with more milk than they require for themselves. These people are called cowkeepers or dairymen.

Tell that at the present time London and most other large manufacturing towns are supplied with milk from the country. Farmers keep a number of cows, and send the milk in upright cans by rail to the various towns through which the railroad passes.

Question the children as to whether they have ever bought milk that had just been taken from the cow; if so, let them describe it. It is warm, and rather thick.

Show some new milk which has been allowed to stand for some hours. *Cream* has risen to the top. When the cream is taken off the milk is called *skimmed* milk. The cream is sold at a higher price than new milk, and new milk than skimmed. A quart of cream is worth three shillings, a quart of new milk fourpence or fivepence.

II. Uses of Milk.—Let the children tell all the uses to which milk is put. Besides being very largely used in the making of butter and cheese, which we will speak about in our next lesson, milk is drunk as a beverage, put into tea and coffee, used in making some kinds of puddings, as rice, sago, and tapioca. Such puddings are called *milk-puddings.* Sometimes milk is used instead of water in making dough for fancy bread. Such bread is called *milk-bread.* Butter is made from the cream, and cheese from both new and skimmed milk.

LESSON 36.—PRODUCTS OF MILK.

First—BUTTER.

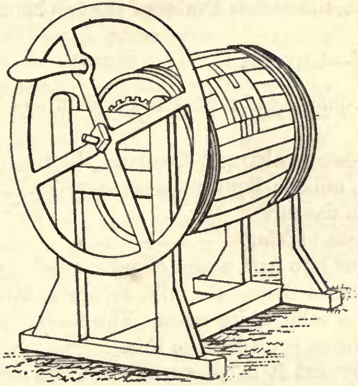
Objects required are, pictures of a dairy, churning, &c., and some new milk.

I. The Dairy.—Show picture, and help children to fancy themselves in one. A square room built in a shady place. Inside walls covered with white, shiny tiles. Floor paved with smooth brick. Round the walls several wooden shelves. Roof made of thatch. Everything in the dairy very clean. On the shelves a number of shallow pans. Some are filled with cream, some with new milk, on the surface of which there is a layer of cream; and some are filled with warm, frothy milk, which has but just been brought in by the cow-boy.

II. Making of the Butter.—By the aid of pictures and experiments lead children to realize the processes.

1. The dairymaid gathers the cream off the milk with an instrument called the *skimmer.* When sufficient has been gathered it is put into the *churn.* Show pictures of the two kinds used.

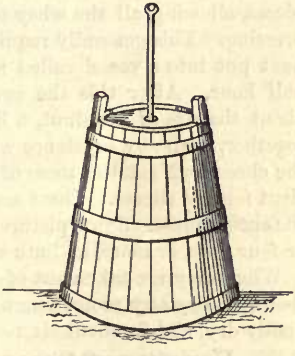
2. Having put the cream into the churn she turns the machine round and round until the butter is made. Illustrate the action of the churn. Put some cream into a round bottle, make it warm, and shake it; children describe what takes place. First, the cream forms itself into little lumps. Tell why. The cream is composed of a number of very small globules of fat, each covered with a delicate skin. The shaking of the bottle breaks the covering and sets the fat free. Each small portion unites and makes the mass of butter. Second, as the shaking is continued the small lumps unite and form large ones. These lumps are the butter. The liquid in the bottle is called *butter-milk*.



Barrel Churn.

Tell the children that the changes which they have seen taking place in the milk when the bottle was shaken take place also in the milk in the churn when it is turned round and round.

3. When the butter is properly formed it is taken out of the churn, laid on a stone slab, and squeezed with the hand so as to press the butter-milk out. This having been done, a small quantity of salt is added, and the whole kneaded together. It is next cut into pieces, weighed, and rolled into bars, or pressed into some other form ready for the market. Such butter is called *fresh butter*.



Upright Churn.

Some farmers keep a large number of cows, and so are able to make more butter than they can sell at the time it is made. They therefore put a larger quantity of salt into it when it is being kneaded. This butter when made is put into tubs called *firkins* or *kits*, and sent to the market under the name of *salt butter*.

A very large quantity of the butter which is used in England is imported from other countries, principally from Holland, Denmark, and Normandy. The imports of butter in 1891 were 239,187,984 lbs., and of margarine 138,368,160 lbs., the declared value of the two being £15,149,386.

Second—CHEESE.

Objects required are, a small quantity of rennet and a picture of a cheese-press.

I. The Principle of Cheese-making.—Compare the cheese with the milk. Cheese is solid, milk is liquid; cheese is yellowish, milk is white; they differ also in flavour.

Illustrate the principle of cheese-making.

Pour a small quantity of *rennet* into half a pint of milk, stir it up and let the children say what takes place—the milk separates into two parts, a watery liquid, and a solid white mass. The former is called *whey*, the latter *curd*. Cheese is made from this.

Take the curd out of the whey, cut it in pieces, children will see that some whey still runs out. When all has drained away, the curd could be made into cheese if the proper implements were at hand. But as they are not, describe what is done.

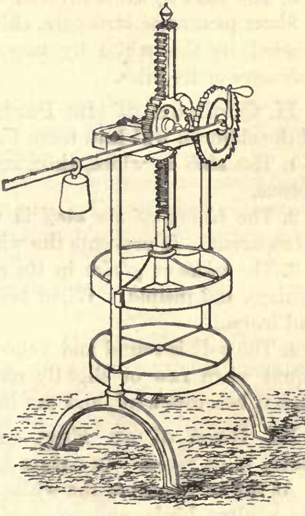
II. The Practice of Cheese-making.—The cheese-maker having warmed the milk, gets the curd from it in the way just shown, and having taken it out of the whey, he cuts it into small pieces, allowing all the whey to drain out which will do so without pressing. This generally requires about half an hour. The curd is next put into a vessel called a cheese-vat, and pressed for another half hour. After this the curd is cut up into very small pieces, about the size of a walnut, a little salt added, and the whole mixed together, with any substance which may be needed to give colour to the cheese. Next the mass of curd is cut into portions, each sufficient for one cheese. These are put into a canvas bag and placed in the cheese-press. Show picture. They are kept in the press for three or four days or more, and are turned every morning.

When they are taken out of the press, the cheeses are placed on a shelf in a dry airy room, where they are repeatedly turned; they gradually dry, and in about six months they are ready for the market.

III. Varieties of Cheese.—Let children name the kinds of cheese which they may know; supply the rest. There are several varieties of cheese, and they are called by various names, some of these being the names of the places where they are made, as Cheshire, Cheddar, and Gloucester cheeses. Stilton cheese is made in Leicestershire, and is considered one of the best kinds, being made of new milk and cream added. The cheese which is made from skimmed milk is not so rich as when the whole milk is used. Of this sort is the Suffolk. Cream cheese is prepared from cream curd which has been placed in a cloth and allowed to drain without the assistance of pressure. This description of cheese is made in Bath and York.

The Scottish dairy districts of Ayrshire, Lanarkshire, Wigton, and Kirkcudbright produce some very fine cheese, being equal to and sold as Cheddar.

Very much of the cheese now sold in London and other large towns of England is imported. Thus there is Dutch cheese, some flat and some round; Canadian cheese, some of which is superior to English Cheddar. Then there is Parmesan cheese, from Parma in Italy, Gruyère, from Switzerland, and Gorgonzola. The imports of cheese of all kinds in 1891 were 228,628,400 lbs., the declared value of which was £4,813,404.



Lever Cheese-press.

Lesson 37.—A HEN'S EGG.

The objects required for this lesson are, two or three hen's eggs—one to be boiled hard—and several kinds of eggs.

I. Parts of an Egg.—Tell the subject of the lesson. Children name the source from which eggs are obtained, and the kind generally used. A hen's egg to be observed and described as a whole: a white oval object, one end of which is broader than the other: hard to the touch, and nearly opaque. Next take the hard-boiled egg to pieces carefully, and so lead the children to discover its parts in the order in which they occur:

1. The *shell* lined with a delicate *skin.*

2. Immediately beneath this is what is called the *white,* or more properly the *glaire.*

3. The *yolk,* which is covered with a very thin skin.

Show picture of structure, children thus see that the yelk is suspended in the white by two delicate threads: these called the *balancers* or treddles.

II. Qualities of the Parts.—Careful observation on the part of the children will lead them to discover the following:

1. The *shell* is white, thin, smooth, hard, brittle, translucent, and porous.

2. The *lining of the shell* is white, very thin, tough, and semi-transparent. It prevents the white from touching the shell.

3. The *white* or *glaire* in its raw state is colourless, liquid, sticky (glairy), and insipid. When boiled it is white, solid, tough, opaque, and insipid.

4. The *yolk* is round and yellow, and has a peculiar flavour. It is liquid when raw or slightly cooked. After being boiled for some time it becomes hard, and can be crumbled.

III. Uses of an Egg.—Let children mention any known, others to be given. In nature for the production of young birds.

As the substance of the white and yolk is nutritious, those laid by the poultry birds, and some of the water-fowl, are used as food. They are prepared in several ways. Boiled in the shells and eaten with bread and butter: taken out of the shells and either boiled or fried: beaten up in milk or wine and eaten raw. Mixed with flour for puddings and cakes, and also with milk for custards and creams.

The glaire is also used in the preparation of some kinds of leather, and in other manufactures, also to clarify liquors.

IV. Quantity of Eggs used.—By consideration of the vast number of people who use eggs, children will conclude that the number of eggs bought and sold must be very great. The farmers and others who keep hens cannot supply the demand, so immense numbers are imported from France, Spain, Belgium, and other countries. In 1891 as many as 1,275,397,680 were brought to this country, the value of the whole being £3,505,522.

The imported eggs are brought in long, shallow boxes called *crates;* each row of eggs is separated by layers of straw.

The imported eggs are bought by merchants, who sell them in smaller quantities to shopkeepers, who in turn sell them in still smaller quantities to those who want to use them. They are sold singly, by the dozen, or by the hundred. Eggs which have only just been laid by the hen are called *new-laid*, and in London and other large towns these always fetch a high price, twopence halfpenny being sometimes paid for one.

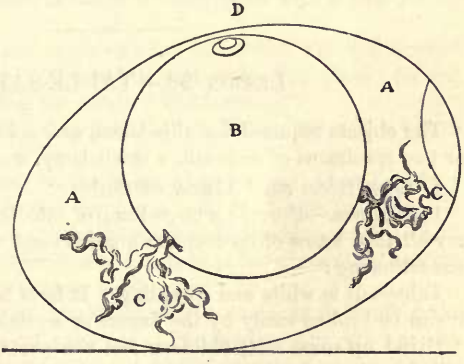
Additional Matter for Elder Children.

1. Value of Eggs as an article of Food.—The white or glaire is composed of albumen and water. The former substance is nourishing and wholesome when slightly cooked.

The yolk contains albumen, a yellow oil, sulphur, and phosphorus. The oil does not suit all constitutions. The sulphur causes the silver spoon which is put into it to turn black, and common metal spoons to have a very unpleasant taste.

The best mode of cooking an egg is that of *poaching*: it should not remain in the water for more than three minutes.

2. The Test for Fresh Eggs.—The white contains water, and as the shell is porous this evaporates, and air enters to take its place; as a matter of course the air-cell at one end of the egg gets larger. Now as air is lighter than water, a stale egg will be lighter than a new-laid one. If then, when an egg is put into water, it has a tendency to float, it may be considered as stale. If the pores of the shell be filled up with grease as soon as the egg is laid the evaporation of the water will be in a great measure prevented, and the egg will continue good for a longer period than otherwise. A French farmer has lately kept eggs fresh for six months by keeping them packed in dry pounded salt.



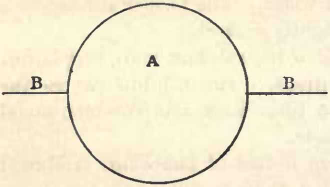
Structure of an Egg.

A A, *White or glaire.* B, *Yolk.* C C, *Balancers or Treddles.* D, *Embryo.*

3. The Mechanism of the Egg.—Direct the attention to the diagram of the structure of the *egg*, when they will see that the yelk is not in the centre of the white but is inclined towards the upper side of the shell, and thus the vesicle which

contains the embryo chick is also brought near the upper side of the shell. Tell the children that whatever way the egg may be turned the yolk always assumes that position. Explain why this is so, and endeavour to lead the children to see the wisdom of the arrangement.

If the yolk A, which is really a globe, had the axis of revolution in the centre B B (see diagram below), it would not move with the change of the position of the egg. But the axis being below the centre it must turn round with every change in the position of the egg. The yolk being, as it were, anchored at the two points C C, and the attachments being below the centre, and the yolk being lighter than the surrounding white, it revolves like a buoy, and the embryo D is thus kept always uppermost, and therefore near the breast of the mother hen when she sits upon the egg during the time of incubation. No other arrangement would bring about the desired end.



The consideration of this beautiful piece of mechanism will not fail to impress the children with a sense of the wisdom and goodness of God in thus preparing such efficient means to work out his ends.

Lesson 38.—TABLE-SALT.

The objects required for this lesson are, a lump of table-salt, one or two specimens of rock-salt, a spirit-lamp, and some water.

I. Qualities and Uses of Salt:

1. *Qualities.*—Provide a large lump of table-salt. Let the children say all they know of its common qualities and uses, and so work out the following:

Table-salt is white and sparkling. It feels hard to the touch, but it can be broken easily by the fingers or scratched by the nails.

Grind up some salt; children feel the parts, they are rough: are called *grains.* On this account salt said to be *granulous.* Each grain is similar in shape; they are crystals, and the salt is said to be *crystalline.*

Place a lump in water. It *falls* to pieces; it dissolves. So said to be *soluble.* Show that as many as six tea-spoonfuls of salt can be dissolved in a tumbler of water. Compare the flavour of salt with other sapid substances. Is different to all. It has a flavour of its own, called *saline*. The water in which the salt was dissolved has the same flavour. Such very salt water is called *brine*.

Compare the state of two pieces of flesh-meat or fish of the same age, one which has been rubbed with salt and one which has not. The former is not tainted, the latter is. What then has the salt done to the substance? Prevented it becoming tainted. It has preserved it. So said to be *preservative*. On this account salt is used to preserve animal substances.

Question children on what they may have noticed respecting the flavour of the white of egg or potatoes. Insipid. What the effect of adding a small quantity of salt. They were made more savoury. This another important use of salt.

In the evening before the lesson is to be given place a lump of salt in a damp place. Now compare it with a piece which has been kept in the dry. What difference? One is wet and the other is dry. As the water was not put on, from whence did the wet salt obtain the water? It absorbed the water out of the air. (Salt because it will do this is said to *deliquesce*.) On this account it ought always to be kept in a dry place.

Tell that when a lump of salt is placed in the fire it breaks into small pieces with a crackling noise. Some of the pieces fly out of the fire. What remains in the fire burns away with a pale yellow flame.

If put into a vessel and made very hot salt melts. On this account it is said to be *fusible*. The melted salt looks like glass. In this state it is used as a glaze for common earthenware.

2. *Uses.*—Let the children name all the uses to which salt is put in the domestic circle.

It is put into the flour by the baker when he makes bread, and by the cook into the flour for puddings and pies; into the water in which potatoes and green vegetables are to be boiled; a small portion is sprinkled over the meat while it is being roasted; and it is eaten dry with fresh meat, potatoes, water-cresses, &c.

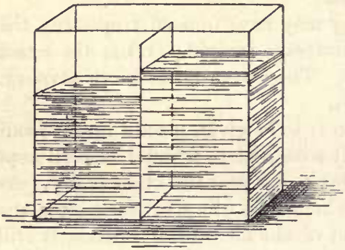
Salt is prepared for use at the salt-works, and sold in large blocks to the salt-merchants, who sell it to the shopkeepers, who in turn sell it to the consumer by weight. At the present time two pounds can be purchased for one penny.

Additional Matter for Elder Children.—As the children will know that the use of salt with various articles of food is very common, tell them how much should be eaten daily, and the reason, illustrating the action of salt in the body.

1. *As to Quantity.*—It has been estimated that every adult requires from $\frac{1}{4}$ to $\frac{1}{2}$ oz. daily. This quantity includes what is used in cooking the food and what is contained naturally in the various substances eaten.

2. *As to the Action of the Salt.*—This can be made clear by one or two simple experiments:

a. Divide a glass vessel into two parts by a piece of bladder; prepare a strong solution of salt and water, and pour it into one of the divisions. Into the other division pour some fresh water tinged with colouring matter. See that the water on both sides of the partition stands at the same level. In the course of time it will be found that the fresh water has passed through the substance of the bladder, and thus causing the salt-water portion to stand at a higher level and the fresh at a lower: the fresh water will pass through the bladder, but the salt water will not.



Tell the children that in like manner when the blood in the veins has a proper amount of salt in it, and water is taken into the stomach, it will pass through the membranes of the blood-vessels and so supply the blood with the liquid it requires. Hence one of the uses of salt is to facilitate the absorption of water into the system.

b. Put some white of egg into fresh water and make it hot: call attention to what takes place. The glaire coagulates. Now mix a very small quantity of muriatic acid—spirits of salts—with water, add a little white of egg, and warm the whole. What takes place? The white of the egg dissolves. Tell that salt contains muriatic acid and soda, the substances are separated by the action of the living body, the acid helps to form the digestive fluid of the stomach (gastric juice), and the soda assists the formation of the bile, a fluid which must be added to the dissolved food before any nourishment can be obtained from it. Hence another use of salt is to assist in the processes of the digestion of the food.

II. The Preparation of Table-salt.—Having provided specimens of rock-salt, both pure and impure, call attention to what takes place when the lumps are struck gently with a hammer. They break into small cubes, those of the purest salt being the most perfect in form. The particular way in which a substance breaks is called its *cleavage*, and so salt is said to have a *cubical cleavage*. All the pieces have a glassy appearance, and so are said to have a *glassy lustre*. By comparing the rock-salt with what is used at table children will see that something must be done to it to fit it for use. If grinding is suggested, pound a small quantity; it is still brown and dirty. What then? It must be purified.

By referring to the solubility of salt, children will see that if the rock-salt is put into water, what is soluble will be held by the water and the earthy portions will settle at the bottom. This is exactly what is done, and the water which contains the salt is called *brine*. Illustrate the process, and compare the brine with the table-salt; the one a colourless liquid, the other a white solid. What then must be done? The water must be got rid of. Illustrate the process. Put a small quantity of the brine in a test-tube and hold it over the flame of a spirit-lamp; the heat causes the water to pass off in vapour, and the salt is left behind in the form of small white crystals.

Tell how the operation is carried on in the salt-works. The brine is pumped into an iron pan about 60 feet long, 20 feet wide, and 18 inches deep. The pan stands on the flues of a furnace. The heat of the fire causes the water to evaporate, and the salt is deposited on the sides and bottom of the pan. More brine is added from time to time until the pan is filled with salt in a solid but wet state. If the evaporation is carried on very slowly the crystals of salt are larger than when the operation is performed very rapidly.

The wet salt is now shovelled out into oblong wooden boxes, the bottoms of which are perforated to allow any water which remains to drain off.

When the water has passed away and the mass of salt has assumed a solid form, it is removed from the boxes and placed in the drying-room.

III. Where Rock-salt is found, and how obtained:

1. *Where found.*—In *England:* At Droitwich in Worcestershire, Northwich in Cheshire, and at Middlesborough in Yorkshire. In *Ireland:* In the neighbourhood of Belfast. It is also found in many parts of the *Continent of Europe*. The most remarkable deposits are those of Poland and Hungary. The largest mine in the world is that near Cracow, which has been worked during the last six hundred years, and still shows no sign of being exhausted.

Rock-salt is found in solid beds or layers of considerable thickness and extent. At Droitwich and Northwich there are two beds, each about one hundred feet thick. The top layer is about seventy-five feet beneath the surface, the second bed is about thirty-two feet below this.

2. *How obtained.*—There are two ways of obtaining the salt from the earth: one is to dig it out much in the same way as coal is dug out; the other is to bore a hole from the surface of the earth to the bed of salt, then to put a pipe down the hole and let water run in. The water, of course, dissolves the salt, and forms brine. This brine is then pumped up and turned into table-salt in the same way as that described above.

At Droitwich and Northwich there are natural brine springs, the water of which is treated in the same manner.

IV. Quantity of Salt produced in England.—From a consideration of the fact that a certain amount of salt is required by every person in our country the children will see that a very large quantity must be produced every year. But that consumed by man is not all that is needed. Very large quantities are used in preserving fish, and still greater quantities in the manufacture of soda and as a glaze for coarse earthenware.

Tell that the quantity of rock and white salt produced in the year 1890 in the United Kingdom was *two million one hundred and forty-six thousand eight hundred and forty-nine tons.*

The children will gain some idea of the immensity of this quantity when it is shown them on the black-board that when reduced to pounds the number is greater by above *four hundred and forty-eight millions than the number of minutes in ten thousand years.*

Lesson 39.—WATER.

I. Distinguishing Qualities and Uses:

1. Negative Qualities.—The negative qualities of water are found—

a. By sense of Sight.—By comparison with coloured bodies children will see that water is neither white, nor blue, nor any other colour. Hence said to be *colourless.*

b. By sense of Taste.—By comparison with sugar, salt, vinegar, &c., children will discover that water has no flavour of its own. Hence said to be *tasteless.*

c. By sense of Smell.—By allowing the children to smell various odorous bodies, and to smell the water after smelling each of the other substances, they will discover that water has no odour of its own. Hence said to be *inodorous.*

It is the absence of these qualities which renders water so adapted for cooking and washing purposes. Having neither colour, flavour, nor odour to impart to what is put into it, each substance retains its own, and in some cases imparts them to the water, as is the case with tea, coffee, cocoa, &c.

2. POSITIVE QUALITIES. — The positive qualities of water are numerous. For example, it is—

a. Refreshing to the person.—Refer to what the children do when they are thirsty. The effect of taking a draught of water. The sense of want of drink satisfied; *thirst quenched,* and person refreshed. Water the natural beverage, and the best to take when thirsty and weary.

b. Cleansing.—Refer to the operation of scrubbing dirty yards, rooms, &c.; water removes the offensive matter and renders the place sweet and wholesome—purifies them. Soap and water remove all the dirt from the skin and from the clothes. Hence the importance of the free use of water in washing both the person and garments. Impress upon the children the fact that dirt is the source of disease, and water is the enemy of dirt.

c. Fertilizing.—Question as to the state of vegetation in our gardens, parks, &c. If there should be a continuance of hot dry weather in the summer, plants droop, grass gets brown. If watered they revive. If seeds, planted in perfectly dry earth and left dry, they do not grow; but if water supplied they soon spring up and come to perfection. The water fertilizes the ground. Hence the value of rain, and the necessity for watering gardens and plants sown in pots.

In those parts of the world where there is no rain and no rivers, as in parts of Egypt, there is no vegetation—such places are called *deserts.*

d. A Solvent.—If the children have had the lesson on TABLE-SALT, refer to it. If not, develop the quality of being *soluble.* Place some salt in the water: the particles are loosed and fall apart, passing into the water. Do the same with sugar—soda. The water takes all these to pieces, dissolves them. On this account it is said to be a *solvent.* Hence the use of water in the domestic circle and in manufactures.

e. An Absorbent.—In the evening preceding the day on which the lesson is to be given, place a shallow vessel full of water in a box, and put by its side another vessel containing some substance with a disagreeable odour—the more volatile the better—shut the box and leave it until wanted. Now tell the children what you did, and call attention to the state of the water. It has the same odour as the substance placed by its side, and yet none of the substance was put in the water. How is this? Explain: a portion of the offensive substance passed off in the form of vapours, and these falling on the surface of the water were taken in and held there: they were absorbed, and because the water does this, it is said to be an *absorbent.* Hence water intended for drinking and cooking purposes should be kept away from the sources of poisonous gases, which are thrown off by decaying animal and vegetable matters.

When water is freely exposed to the air a large portion is absorbed, sufficient to support the life of all aquatic animals.

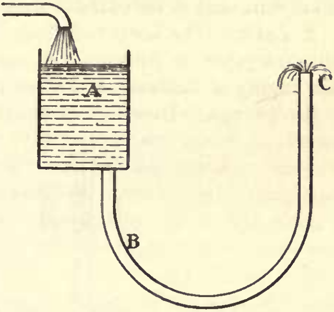
f. Volatile.—Boil some water in a glass vessel with narrow neck. Children to describe accurately what they observe. The water is in a state of ebullition; between the surface of the water and the top of the flask an apparent void; immediately above the neck a quantity of steam. Tell that the space between the surface of the water and the top of the flask is really filled with the vapour of water—true steam—which is always invisible, and what they call steam is the vapour which has been cooled by the air, and is really small particles of water. Thus, then, they see that water will pass off in the form of vapour—will evaporate. On this account it is said to be *volatile.* Hence the use of water to produce steam for the moving of machinery. Hence also the possibility of drying anything which has been immersed in water.

By holding a cold plate in the steam, the children will see that as soon as the vapour comes in contact with the cold substance it is turned into water again. It is said to be *condensed.* Now take a little brine, apply heat, the water passed off in the form of vapour leaving the salt behind. Condense some of the vapour, and let a child taste the water thus produced. It is tasteless, proving that none of the salt has passed off with the vapour.

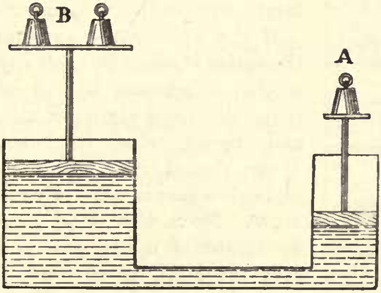
The children will see that it is possible to obtain fresh water from salt water by evaporation and condensation. Tell that it is by this means that at sea the sailors are frequently supplied with fresh water. The apparatus in which the operation is performed consists of an *evaporator*, *condenser*, and *refrigerator.*

g. Penetrating.—Take some porous body, say an old brick, pour some water on one side. Call attention to what takes place. The water passes into all the pores, and after a time makes the whole brick wet. On this account the water is said to be penetrating. Wherever it finds pores it will pass into them. If the pores are very small, and the supply of water be continuous, the water will rise for a considerable height; hence the wet walls when the lower courses of bricks rest on damp earth, and hence also the importance of cutting off the supply of water. (See lesson on the BUILDING OF A HOUSE.)

h. It will find its level.—Either have a contrivance or make a diagram to illustrate this property of water. Suppose the cistern A, placed on the top of a house and filled with water; a pipe B, in the bottom of cistern and carried up to C, the water will rise in the pipe to C and flow out. As long as the cistern is kept full the water will flow out at C. Show the usefulness of this in the supply of water to our dwelling-houses, factories, &c., and in the construction of fountains.



i. Incompressible.—If the children have had the lesson on COMPRESSIBILITY, refer to it; if not, tell of the experiment, and show the application, illustrating by a diagram the property which water has of communicating pressure to all parts of its surface when confined in a vessel.



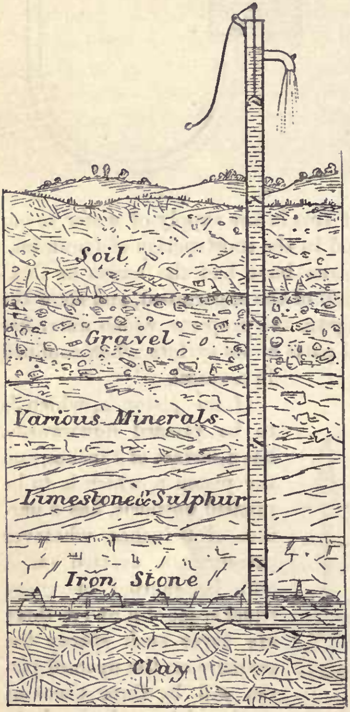
If the piston A, which is to be pressed downwards, has a surface of 3 inches, and the piston B, which is to be pressed upwards, has a surface of 9 inches, whatever pressure be exerted on A will be exerted on every equal space of B, and as there are three such spaces the pressure on the upward piston will be three times as great as that exerted on A. Now suppose the piston A be made to receive a pressure equal to 50 lbs., then the piston B will receive three times 50 lbs. or 150 lbs. pressure. This is the principle of the hydraulic press.

II. The Sources of our Water Supply.—Let the children name any known, correct errors, and supply what is needed, and so work out that the water which is used is obtained from one or other of the following sources:

1. *Rivers.*—Unless the rivers are polluted by sewerage or the refuse of manufactures, as is the case with some of the rivers of Yorkshire and other parts of England.

2. *Lakes.*—The waters of Loch Katrine in Scotland are conveyed through pipes or passages a distance of many miles to Glasgow for the supply of that city, and those of Thirlmere to Manchester.

3. *Springs.*—In some cases springs rise to the surface of the ground and form the source of rivers. In other cases the water is reached by sinking wells, and the water is either pumped up or rises to the surface, according to the depth of the well. Deep wells whose waters thus rise to the level or above the level of the land are called *artesian wells.* The water which supplies the fountains at Trafalgar Square, London, comes from such a well. The water obtained from very deep wells is much warmer than that obtained from ordinary springs.



If the water which supplies the springs passes through any soluble substances it will of course dissolve a portion of each and retain what it holds. Water thus charged with mineral substances is called *mineral water.* Make this point clear by means of a diagram, and give the localities of some of the mineral springs in Great Britain:—

a. In England.—Harrogate, Buxton, Matlock, Malvern, Bath, Leamington, Cheltenham, Epsom, and Tunbridge Wells.

b. In Scotland.—Strathpeffer, Bridge of Allan, Moffat, Dunblane, Pitcaithly, and Bonnington.

c. In Ireland.—Kilkenny, Mallow, and Swanlinbar in co. Cavan.

Many of these places are visited by a large number of invalids for the purpose of drinking the waters.

4. *Rain.*—In some places all the rain which falls upon the houses is collected and stored up for use. In districts where the atmosphere is not contaminated by smoke or noxious vapours such water is the purest which can be obtained.

In London and other large towns the water which is needed for use is supplied by companies. These companies collect the water from some pure source, store up a certain quantity, which is filtered and conveyed from the storage grounds called the *reservoirs* through pipes into the houses. Large pipes called *mains* are laid along the principal roads, from these smaller ones branch off to the streets, and from these still smaller ones are led into every house; these are called *supply pipes;* they deliver the water into a cistern. When the cistern is full the supply is shut off by the action of a ball tap, which the householder is bound to keep in working order. From the cistern the water passes to various parts of the house.

The water companies have the right to charge a certain price for the water supplied—this is called the *water rent,* and in London is at a certain rate on the value of the house. If the water rent is not paid the companies have the right to cut off the supply of water to that house.

LESSON 40.—OLIVE-OIL.

The teacher is supposed to be giving the lesson. The objects required for the lesson are, some pure olive-oil and some of the more common sorts, a glass of water, a piece of cotton wick, a picture of the olive-tree, and if possible a few olives.

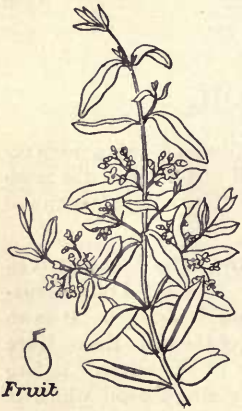
I. Qualities.—There are very few children who have not seen salad oil, and some may even have tasted it. This salad oil is sometimes called *Florence oil*, but its proper name is *olive-oil.* It is so named because it is obtained from the fruit of the olive-tree. Here is a picture of the tree, and here are some of the olives. Before you learn how it is obtained, you must examine the oil which is in the glass and describe it. You see that it is a liquid, of a pale yellow colour, semi-transparent, soft to the touch, inodorous, and insipid.

Some of the oil has been poured into a glass of water. It floats on the top. Why is this? Yes, it does so because it is lighter than water. The water which has the oil on the top shall now be shaken. You see that the oil has been broken into a number of little drops, which float in the water, and all come to the top again as soon as the water is at rest: the oil will not mix with the water.

Here is a small lamp. Some olive-oil has been put on the wick, and now that it is well soaked a lighted match shall be put to it. You see how nicely it burns, and what a white light it gives. You know what it is called because of this? Yes, *inflammable.* It would be a very good oil to burn in lamps, were it not that it is sold at a very high price compared with colza and other oils which are used for the same purpose.

If a little of the oil is poured on to a piece of calico or cloth, it will wet it, but not in the same way as water does. It cannot be dried, and so there will be a mark which is called a *grease spot.* This spot cannot be taken out without washing the material which is greased. You must be very careful not to spill any oil on your clothes, or on the table-cloth, &c.

II. Uses of the Oil.—There are several small bottles on the table filled with olive-oil. You see that some are much darker in colour than the others. The lightest coloured is the purest. It is this kind which is used as food. The people who live in the country where the olives grow use this oil for the same purposes as we use butter and cream.



Branch of Olive-tree.

In our country it is eaten with salads, and it is also used to cook fish in. The little fishes called *sardines* are always cooked in olive-oil.

The dark-coloured common kinds are used for soap-making, and to sprinkle on wool when it is being spun ready to be made into cloth.

III. The Tree.—You must now learn something about the olive-tree, and how the oil is obtained. Here is a picture of a branch. It is a pretty evergreen tree with a stem about nine feet high. The leaves are of a grayish green colour; the flowers are small, white, and sweet-scented. The *fruit,* as you see by looking at those in the bottle, are about the size and shape of the damson plum. The pulp or flesh is rough, bitter, and oily. It is from this that the oil is obtained.

IV. How the Oil is obtained.—When the oil is wanted, the fruit is taken off the tree as soon as it is ripe, and put into bags made of a kind of canvas. The bags are then pressed rather gently, and the oil is squeezed out. This first oil is of a very light brown colour, and is very pure. It is sold at a high price, a pint being worth one shilling and fourpence.

When no more oil will run out by the gentle pressure, the pulp is made warm and then it is pressed much harder. The oil which is pressed out by this means is much darker in colour and is considered a common kind. It is this which is sold as *Florence oil.*

But the warming and pressing does not get all the oil out of the pulp, so it is now boiled in water, when a much more common kind of oil is obtained. It is this kind that is used for making soap, and to be put on the wool when it is being made into cloth.

In 1891 the importation of olive-oil was 18,107 tuns, the declared value of which was £733,435.

V. Different Kinds of Vegetable Oils.—There are other kinds of oils which are obtained from the fruit and seeds of plants. Here is *linseed-oil*, which is pressed out of the seeds of the flax plant. You see that it is of a dark brown colour, and if you smell and taste it you will find that it is very unpleasant and would not do to be used as food. But this oil is very useful to painters, because it is the best they can get to mix their paints with.

Here is *colza-oil*, which is used to burn in lamps; it is pressed out of a kind of rape seed. Then there is *castor-oil*, which is used as a medicine. This oil is pressed out of the seeds of the castor-oil plant. Then there is *palm-oil*, which you see differs from all the other oils in being a solid. It is obtained from the fruit of the oil-palm.

Many other kinds of vegetable oils are now used for various purposes in manufacture. Among these may be noticed cotton-seed oil, large quantities of which are annually imported from America. In 1891 the imports of vegetable oils were: castor, 166,765 cwts.; cocoa, 186,469 cwts.; palm, 1,018,420 cwts.; various seed-oils, 460,220 cwts.

SECTION III.—CLOTHING MATERIALS.

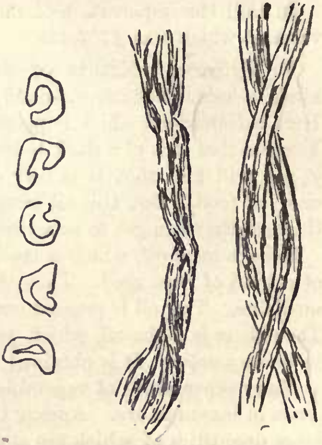
Lesson 41.—CALICO AND COTTON.

I. Introduction.—Tell subject of lesson. Show specimens of calico. Children to give the qualities which render it useful; as, soft, pliable, warm to the touch, light, can be washed, and is inexpensive.

Direct attention to its structure. Made up of a number of threads which interlace each other, each thread composed of a number of very fine fibres twisted together.

II. The Raw Material.—If possible show raw cotton with seed in, and a picture of tree with ripe pods. Children will thus learn that cotton is a vegetable substance, the downy covering which surrounds the seeds. The pods are filled with cotton, and the root end of the fibres are fastened to the seeds.

Cotton Plant.



Section of Cotton Fibre and whole Fibre.

Lay a few of the fibres out on a piece of black paper, when it will be seen that the fibres vary in length, and appear to be straight. Make diagram of the real structure as seen under microscope—fibres really twisted, twists varying from one hundred to three hundred in an inch.

This peculiar structure renders the fibre adapted to the making of a thread. If each fibre were cylindrical its shortness would prevent it holding together. But by their peculiar form, when twisted, the fibres hold together.

III. The Preparation of the Cotton for the Market.—

By regarding the nature of the material and its mode of growth, children will be able to determine what must be done. Supply the exact information:

1. *Gathering.*—Cotton gathered by hand. This is done by carefully pulling out the whole of the contents of the *pod* or *boll.* A good picker will gather as much as 200 lbs. of cotton a day.

2. *Separating the fibres*, or *lint* as it is called, from the seeds. This operation is called *ginning*, and is always done in the neighbourhood of the cotton plantations. The separation is effected by passing the cotton through a machine which has a roller covered with leather, and immediately below this two sharp knives, so arranged that their edges are very near the roller—one on each side of it. When the roller moves it draws the lint in, and the edges of the knives separate the seeds from the fibres. The operation also partially cleanses the cotton from any foreign substance which may have clung to it. The seeds are collected and sold for the sake of the oil which they contain.

3. *Packing or Baling.*—The loose cotton is next gathered up, put into bags and subjected to great pressure. When it leaves the press it is called a *bale;* each bale weighs about 350 lbs. In this state it is imported into this country, mostly to Liverpool. A pound of raw cotton at the present time is worth about sixpence or sevenpence.

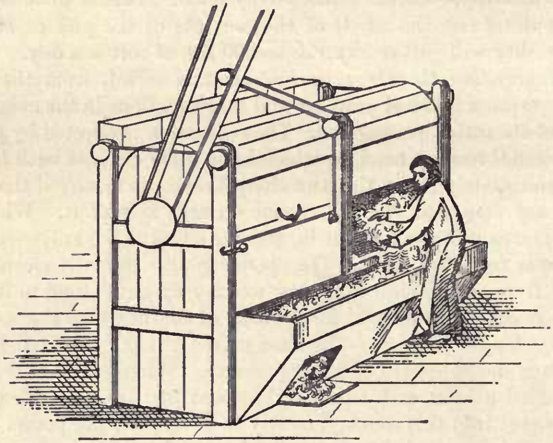
IV. The Processes of converting the Raw Cotton into Yarn.

1. *Sorting and Mixing.*—Lead the children to see the necessity for these operations by reference to the different kinds of fibres. Some long—one inch to one inch and half—this called *long staple:* some short—one-quarter to three-quarters of inch, these called *short staple.* Again, all the long staple not of the same quality, nor yet the short, so the different qualities of each mixed together, all the long staple being put together, and all the short.

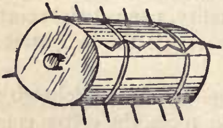
The contents of all the bags are mixed together in the following manner. A space is cleared on the floor of the room, the cotton contained in the first bag is scattered over this space so as exactly to cover it; the contents of the second bag are in like manner spread over the first, and the cotton in all the other bags is disposed in a similar manner. Men and boys tread down the heap, which is called a *bing* or *bunker*, until at length it rises up in shape and dimensions very much like a large hay-stack.

Whenever a supply of cotton is needed for the workers in the factory it is torn down with a rake from top to bottom, by which means the contents of the different bags are collected together in a mass of uniform quality.

2. *Willowing and Opening.*—If a piece of raw cotton is at hand, children will see that the fibres are matted together—the effect of the pressing. It is necessary to draw these apart in order to make them into yarn. Tell how this is done. The cotton, as it is torn down from the bing, is put into a machine called a *willow.* This consists of a box containing a conical wooden beam studded over with iron spikes, this beam is made to turn round five or six hundred times in a minute. The cotton, when put into this machine, is caught by the spikes, tossed about and shaken with great violence, and gradually driven forward to the other end, loose, and freed from dust and any other dirt which may have got mixed with it.



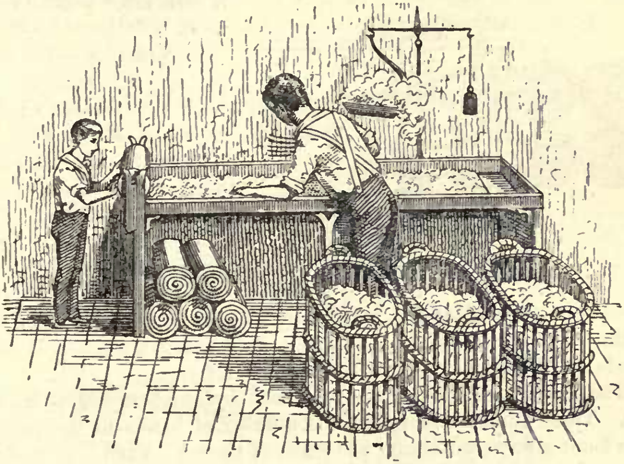
Willowing Machine.



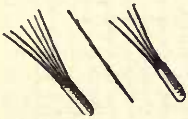
Portion of the Beam.

3. *Scutching or Lapping.*—Children will see that when the cotton leaves the willow the fibres are in all directions, and as they could

not be worked in this state they are laid in the same direction, and formed in a continuous sheet or web, which when finished has the appearance of a sheet of wadding. Show piece. In the case of the best kinds of cotton this process is carried on by hand, the cotton being placed on a strip of canvas fastened to a frame, and beaten with an instrument called a *fan*. After it is beaten it is wound on a roller. The cotton is now said to be *lapped*.



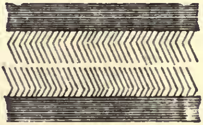
Forming Laps by Hand.



Fans.

4. *Carding.*—In this process every individual fibre is laid parallel to each other, formed into a thin film which is afterwards drawn into a continuous ribbon-like piece called a *sliver*, which is round, thick, soft, untwisted, and possessing no strength.

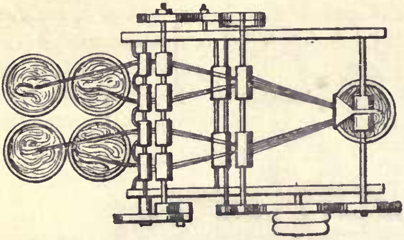
Let the children suggest how this might be made stronger. By twisting. But then the cord would be thick, and unfitted for the purposes to which it is needed. It must therefore be made thinner and yet stronger. Tell how this is accomplished, namely by—



Carding Bands.

5. *Doubling and Drawing.*—Several slivers are combined and drawn out to the dimensions of one of the component parts. While being drawn it is also slightly twisted.

The process is repeated several times under the names of *slubbing* and *roving.* It is made longer, thinner, and yet stronger, by being a little more twisted each time.



Drawing Head.

6. *Spinning.*—By comparing the last roving with the threads of the calico, children will see that the former is thicker, weaker, and less twisted than the latter. The change is effected by a process called *spinning,* in which the roving is still further lengthened and strengthened by being twisted. When the cotton leaves the spinning machine it is called *yarn.* It is now made up into *hanks* and sold to the weaver.

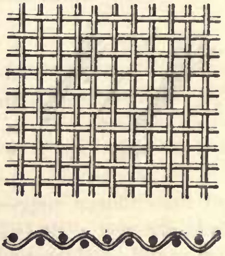
The fineness of the yarn is expressed by numbers 40, 50, 60, 80, &c. These numbers represent the number of hanks to the pound, the hank always containing 840 yards of thread. Yarn is now often spun of the No. 700. A pound of this fineness would contain 588,000 yards or about 334 miles.

V. The Processes of Weaving.—By comparing the yarn in hank with the calico the children will see that by some means the threads must have been laid straight, placed side by side, and interlaced. Tell, and illustrate by reference to darning, how these changes are effected.

1. *Winding.*—In this operation the yarn is transferred from the hank to a reel called a *bobbin,* to prepare for—

2. *Warping.*—A number of bobbins, 300 to 500, are placed in a machine called a *crest,* and the threads are wound in parallel order upon a beam to the length of 3000 to 5000 yards. This is to form the *warp.*

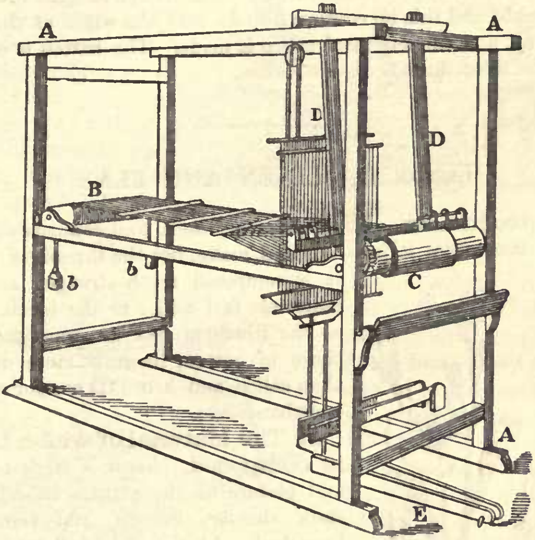
3. *Sizing.*—The yarn thus warped is immersed in a fluid composition of water and starch for the purpose of strengthening the threads.



The principle of Weaving. The black dots represent the threads of the warps, the wavy line the woof.

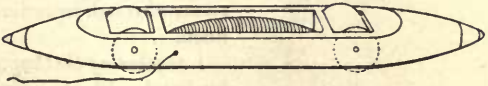
4. *Beaming.*—When the weaver receives the warp of yarn from the warper he proceeds to lay it out in regular order upon the yarn-beam of his loom so as to form the breadth of the intended calico.

5. *Drawing in.*—The warp having been wound on the warp-beam, each individual thread is next passed through a loop in a set of strings fastened at the top and bottom to thin bars of wood. The whole set is called a *heald* or *heddle,* one half of the threads, say all the even numbers 2, 4, 6, 8, &c., are put through the loops of one heald, and the other half, say all the odd numbers 1, 3, 5, 7, &c., through the loops of the second heald. The ends of all the threads are then placed through a set of wires called the *reed.*



Hand Loom.—*A A A, Frame. B C, Rollers to which are attached the threads of the warp. B is called the yarn roller. C, The cloth begun. b b, Weights to keep warp tight. D D, The batten. E, Treadles.*

6. *Weaving.*—By this process the threads of the warp are interlaced by cross threads called the *woof* The healds are placed in the loom, one behind the other, and in hand-weaving looms are connected with the treadles. When the weaver moves the treadles he first lifts up the heald through whose



Shuttle in Frame.

loops are passed the threads represented by the even numbers 2, 4, 6, 8, &c. He then throws with his right hand the *shuttle*, on which is wound the yarn for the woof. He next lifts up the heald through whose loops the threads represented by the odd numbers are passed, and then with his left hand throws the shuttle, and thus interlaces the threads, and this he continues to do until the whole of the warp is used up, and the length of calico is made. The batten is used to bring the woof-threads close together.

Lesson 42.—LINEN AND FLAX.

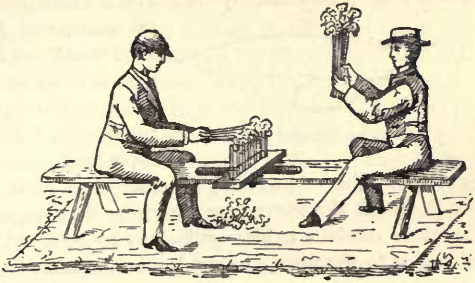
I. Introduction.—Show piece of linen, and compare it with calico. Resembles it in colour and make, but the threads of which it is composed much stronger, and the materials feel colder to the touch. But as the fibres of flax are stronger than those of cotton, linen is more durable than calico, and hence its use for collars, wristbands, &c.

Flax Plant.

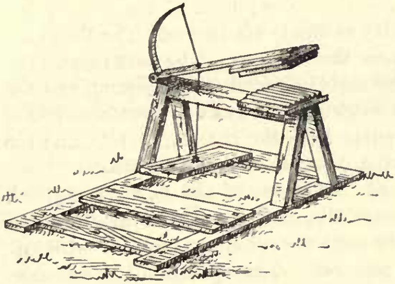
II. The Material of which Linen is composed.—Show a stick of flax and picture of the plant. Describe it: stalk slender, smooth, and somewhat branched. At the end of the branches a number of blue flowers. The flowers give place to pods or capsules, each of which contains ten flat oblong seeds of a brown colour: these the linseed of commerce. Explain which part of the stem supplies the fibres, and, by the same method as that pursued in the other lessons on the same subjects, work out the processes which the raw material passes through in order to convert it into linen.

1. *Gathering the Crop.*—Plants uprooted by hand. Plants seized just below the seed-boll and removed perpendicularly. The pulled flax is laid in handfuls and crossed, the root-ends all lying one way.

2. *Seeding or Rippling.*—Handfuls are carried by children to the rippler, who spreads out each handful and draws the stem through the teeth of an iron comb. The seeds are carefully gathered up and sold for the sake of the oil which they contain. The oil, which is called *linseed-oil*, is obtained by pressing the seeds. The crushed mass that remains after the oil is expressed is called *oil-cake*, and is used for fattening cattle. When rippled the flax is tied loosely in bundles of small size: these are called *beets.*



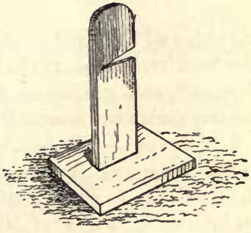
Rippling.



The Brake.

3. *Retting.*—The object of this process is to separate the fibre from the woody portion of the stem. It is accomplished by placing the beets in water for some time, from eight to twelve days according to the state of the weather. After a short time fermentation commences, and the fibres are loosened from the wood. The flax is next taken out of the pond and placed on the banks to drain for a few hours, after which it is spread out evenly to dry.

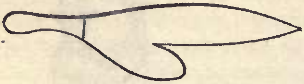
4. *Breaking.*—When dry the flax is again bound in bundles and subjected to pressure of various kinds so as to break the woody portions, and thus render it more easy to get the fibres.



Scutching Frame.

5. *Scutching.*—By means of this process the fibre is freed from the broken woody matter, and so rendered fit for the market. The operation is some-

times performed by machinery, and sometimes by hand. When the latter, it is performed by means of a board set upright in a block of wood, and having a horizontal slit about three feet from the ground. The bruised flax is held in the left hand and inserted in the slit so as to project to the right. Here it is repeatedly struck with a flat sword or *scutcher*, the blows being directed close to the slit, through which the flax is at the same time drawn by degrees, so that every part of the stem receives a blow sufficient to beat out the pieces of wood adhering to the fibre, and to leave the latter loose and free for the next process.

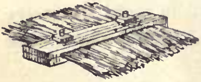


The Scutcher.

The operation causes a waste of fibre, and this waste is called *scutching tow,* and is used for the manufacture of twine and sacking.

6. *Dividing the Flax into lengths.*—The length of the stem of flax varies from twenty-six to thirty or thirty-six inches. The fibres are not of equal quality throughout their length. The part nearest the root is coarse and strong, the middle part fine and strong, and the upper part still finer, but not so strong. The flax is therefore divided into three lengths, and the parts from the bottom, middle, and top are collected into separate heaps, or *sticks* as they are called.

7. *Heckling.*—By this process the fibres of the flax are cleaned, split, separated into their finest fibrils, and arranged in parallel order, and the short fibres which are unfit for spinning, together with any dust or dirt, are completely removed. The operation is performed by drawing the fibres through combs furnished with iron teeth set at equal distances apart. The flax is thus divided into two parts—the short fibres which remain between the teeth of the heckle, and are from time to time removed, and the long fibres, called *line*, which remain in the hand of the heckler. When perfectly heckled the line of flax consists of long, fine, soft, and glistening fibres, of a bright silver-gray or yellowish colour, somewhat resembling silk in appearance.



8. *Spinning.*—The heckled flax is now prepared for spinning much in the same way as cotton, and the spinning differs but little from the operation in either cotton or wool. When spun the yarn is made up into thick skeins, of 300 yards, called *leas*, and 10 of these form a *hank*, and 20 hanks form a *bundle.* The size or fineness of linen yarn is reckoned by the number of leas to the pound weight, three hundred, four hundred, and even more, are contained in a pound.

III. Historical Notes on the Linen Manufacture.—The manufacture of linen dates from a very early period in the history of the world. It is certain that among the Egyptians in the time of Joseph the art of spinning and weaving the fibres of flax was at a high pitch; and the cloths which were wound round the mummies were made of flax. It is certain also that the Egyptians in the days of Solomon exported linen yarn and fine linen to the kingdom of Israel. From Egypt the manufacture spread to Greece and Rome, and in the course of time to the other countries of Europe. It was introduced into England from Flanders in the thirteenth century, and thence into Ireland in the seventeenth century.

At the present time (1891) there are in the United Kingdom 462 flax and hemp factories, using 49,230 looms, and employing 118,155 persons.

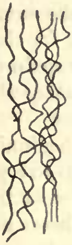
Lesson 43.—WOOL AND WOOLLEN CLOTH.

The objects required for this lesson are, a piece of sheep-skin with the wool (a piece off the shin-bone will do), some woollen yarn, and several specimens of woollen cloth.

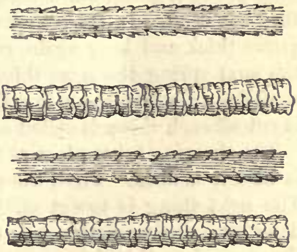
I. Introduction.—Let the children name the different materials used for clothing, as cotton, linen, silk, wool, fur, leather, and the source of each. Thus bring out that some are vegetable, others animal substances. Tell that the present lesson will be on *Wool.*

II. Qualities of Wool.—If possible give each child a small portion of wool, and having examined it, bring out its qualities, as white, soft, light, flexible, tough, fibrous, compressible, elastic, porous, and absorbent. If these qualities are not known, develop them. (Study method of dealing with qualities in previous lessons.)

Direct attention more closely to the character of the filaments of the wool —they are waved. Show picture of their appearance when examined through a microscope: they are covered with scales overlapping each other, and projecting wherever a bend occurs in the fibre.



Fibres of Wool.



Fibres of Wool as seen under microscope.

Let a child place some dry wool to his cheek, and say what he perceives. He will say that it feels warm. Place something before the fire until it is fairly hot. Let this be placed on one cheek, and some wool on the other. The child will discover that the wool does not feel warm in the same way as the heated article does. Tell that the wool is not in itself warm in the same way that a fire is warm; but when it is placed on the face, or on any other part of the body, it does not allow the heat of the blood to pass out—the heat will not pass through it—and so keeps the person warm. (Wool is a non-conductor of heat.)

III. Uses to which Wool is put.—Let the children name what they know. Tell the rest, and thus work out the following:

Being soft, flexible, and a non-conductor of heat, it is woven into cloth, which is made into various articles of clothing. Blankets are made of wool, and some kinds of carpets. Wool is also spun into a thread to darn with, and one kind of thread called Berlin wool is used in making fancy wool work.

IV. The way in which Wool is obtained:

1. SHEEP SHEARING.—Children in agricultural districts will know this, but few if any town children are acquainted with the process. If the lesson on FUR has been given, ask how the skins were obtained—animals killed for the sake of the skin. Tell that this is not the case in respect to the wool of the sheep. Most of the wool which is used is taken off the sheep while it is alive, and this is done without hurting the animal. Tell the way in which it is obtained. In the winter the wool on the sheep gets thick and long, and when spring comes some of this long wool falls off. Now the farmers who keep flocks of sheep know this, and so, instead of letting it fall off, they cut it off. In the course of the summer and autumn the wool grows thick and long again, ready for the next winter, and then in the next spring the same thing is again done. This cutting off the wool from the live sheep is called *sheep-shearing*, and the wool which is cut off each sheep is called a *fleece.*

The shearing takes place at the beginning of the summer, and this is how it is done. First, the sheep are prepared by being *washed.* The next thing is to cut off the wool from the sheep, and this is done by a shearer with a pair of shears made for the purpose. The shearer seizes the sheep, and sets it on its hind legs. He keeps the sheep down with his left hand, and with his right hand cuts off the fleece from the head and neck as far as the shoulders, and also from the under part of the body. The animal's head is then held down sideways, and the shearer, placing one of his legs on each side of the neck, cuts off the wool from one side with his right hand and then from the other side with his left hand. After this he cuts the wool from off the back and from any other part left uncut.

When the fleece has been removed from the sheep it is rolled up and carefully put away. When the whole of the flock has been sheared the farmer sells the fleeces to the wool merchant, or *wool stapler* as he is called, who in turn sells them to those people who prepare it for the weaver.

In the case of sheep which are killed for food the wool is sold with the skins. In some cases it is removed from them by the man who prepares the skins for use as leather. In many cases, however, the wool, if long, is retained on the skins, and made into rugs or mats for house and carriage use.

Large numbers of Astrakhan sheep and lambs' skins—usually black—are imported with the wool on—"in wool," as it is termed—and are dressed and used as furs for personal wear. The chief seat of this trade is at Bermondsey in London.

2. THE DIFFERENT KINDS OF WOOL.—If possible, show children pieces of skin of Leicestershire and South Down sheep. Call attention to the character of the wool on each. The former much longer than the latter. Tell that each individual fibre of wool is called a *staple*, and hence wools are spoken of as either long or short stapled.

From a careful examination of the specimens or pictures children will see that some are less wavy than others, and have fewer teeth or *serratures*. Tell that those which are the more serrated are called *carding wools* and those which are less serrated *combing wools*.

The former are used for what are termed *woollen goods*, as broad cloths, the latter for *worsted fabrics*, such as alpacas, poplins, and the like.

The term *worsted* is said to be derived from a village of that name in Norfolk, where this manufacture was first carried on. Eighty years ago worsted goods were the chief productions of Norwich, the county town of Norfolk.

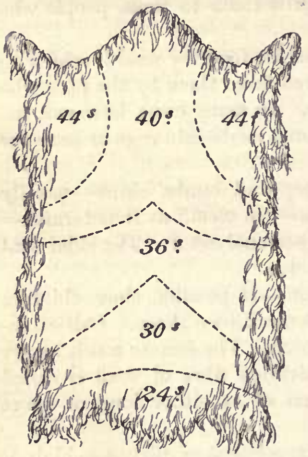
3. THE PROCESSES IN THE MANUFACTURE OF WOOLLEN YARN.—By comparing the raw wool with the yarn when it is ready for the loom, and this again with a piece of broad cloth, the children will see the necessity for some operations to fit the one for the other, and by comparing one step in the process with the next the necessity for some further process. In some cases the consideration of the nature of the material may lead the class to suggest the probable operation. When this is the case tell the exact mode, and as far as possible illustrate each

process by the specimens and drawings, and so work out the following points:

a. Sorting.—Show the necessity for this by drawing a diagram of a fleece of wool, with the lines and figures as below, telling that the figures represent the number of hanks of yarn which can be spun out of a pound of wool taken from the different parts of the fleece. The children will thus see that the most valuable wool is that which grows on the breast and the least so that which grows near the tail.

The following interesting facts may be given:—A pound of wool from the breast will produce 44 hanks. In each hank there are 560 yards. Now 560 × 44 = 24,640 yards, or 14 miles. On the other hand, a pound of wool from the tail part will only produce 24 hanks. Now 24 × 560 = 13,440 yards, or 7 miles 1120 yards, a little more than half the former.

The sorter unrolls the fleeces, lays them flat on a table, removes any pieces of straw or dirt which have been left on them, and divides the sorts of wool, as shown in the diagram, keeping each separate.



Division of Fleece, showing the number of hanks to the pound from different parts of the Fleece.

b. Scouring and Washing.—Show piece of wool as imported. It is dirty and greasy. By reference to how children get rid of grease off their hands they will suggest the mode here adopted. Wool placed in large vessels of boiling water and soap, stirred and boiled until all the grease is dissolved and the dirt taken out.

When clean the wool is passed between rollers to squeeze out all the water. It is then passed into a box in which is a revolving fan which separates the fibres and scatters them all over the room. By this means the wool becomes nearly dry. It is afterwards thoroughly dried by means of hot air. (In some cases the wool is now dyed, but not always.) The wool is now oiled, about 4 lbs. of oil being put on 20 lbs. of wool.

c. Preparing and Combing.—By examination of some wool which has been washed children will see that the fibres are all intermingled, and in that state could not be made into yarn. They must be laid even. This is accomplished in the preparing and combing machines. (These are too complicated to be described to the children.) Show specimen of combed wool, when the children will see that it has become a thickish kind of yarn.

d. Drawing and Roving.—If a child is allowed to pull the specimen of combed wool he will find that it is not strong enough to work, and too thick, so it must be made longer, thinner, and stronger. Tell that these qualities are given it in what are called the *drawing* and *roving machines.* The wool undergoes several processes of drawing, each time becoming thinner, longer, and stronger, and slightly twisted, as was the case with cotton.

e. Spinning.—Show some spun yarn, and tell that this process is accomplished in a machine called the *spinning-jenny.* When the yarn leaves the spinning machine it is ready for the weaver.

4. PROCESSES IN THE MANUFACTURE OF WOOLLEN CLOTH.—Tell how the yarn is prepared for the loom and woven. See lesson on CALICO AND COTTON.

Compare a piece of material as it leaves the loom with a piece of broad cloth, when the children will see that in the former both the warp and the woof can be seen, and can be separated; while in the latter neither is the case. Tell how the change is effected:

a. Cloth scoured, to get rid of the grease.

b. Dried.—Cloth stretched on rails or hooks in tenter ground.

c. Burled.—All irregular threads, knots, &c., removed.

d. Mulled or fulled.—Cloth beaten so as to cause the little serratures on the fibre of wool to interlock or cause the wool to felt. The fabric will not now unravel.

e. Teazed.—Loose fibre of wool raised to surface so as to form the nap. This done by means of a teazle, the seed-vessel of a kind of thistle.

f. Sheared.—The loose fibres cut so as to give the cloth a smooth surface.

g. Finished.—All blemishes removed and carefully brushed.

h. Pressed.—Several folds of cloth placed between polished boards and subjected to great pressure.

Note. In the manufacture of worsted goods the fabrics leave the loom in a finished state, and only need to be examined.

V. Additional Notes on the Woollen Trade:

1. *The Quantities used.*—From a consideration of the vast numbers of people in England who constantly need woollen fabrics the children will readily see that immense quantities of raw wool will be required to supply the want.

Tell that the total quantity of wool and woollen-yarn imported into this country in the year 1891 was 757,710,852 lbs., equal to the fleeces of more than 200,000,000 sheep. The value of the raw material was £29,953,955.

Very much of the wool used is imported from Australia, South Africa, and other countries.

2. *The Antiquity of the Trade.*—Wool was the staple material of the weavers of Palestine, Syria, Greece, Italy, and Spain in ancient times. Some of these countries were spoken of as "flock abounding." The art of making woollen garments was first introduced into this country by the Romans. The spinning of the wool was the work of the Saxon ladies and their daughters: these young women were called *spinsters.* When William of Normandy invaded England he brought with him the Flemings, who very much improved the manufacture.

In Henry II.'s reign "Cloth Fair," near Smithfield, London, was established, and the wool trade became a settled industry of this country.

Edward III. invited many more Flemings into England, placed them in different parts of the country, and forbade the export of wool and the import of foreign cloth.

In the time of Henry VIII. the spinning-wheel was invented, which continued to be the only method of producing the yarn for the weavers till about the year 1780, when the spinning-jenny was invented. From that time to the present improvements have been made both in the spinning machines and in the looms.

At the close of 1890 there were 2671 woollen factories in the United Kingdom. The number of persons employed in these was 301,556.

LESSON 44.—SILK.

I. Introduction.—Take some article of dress made of silk. Let the children say all they can about it; as to the nature of the material of which it is made—silk; show some, and get its qualities: an animal substance, composed of a number of very fine fibres, which are soft, pliable, strong, and lustrous.

II. The Source of the Material:

1. Show cocoon, or picture, of an ordinary mulberry-feeding moth, when the children will see that it consists of two portions—an outer, which is loose and flossy, and an inner, which is hard and compact, and has no openings of any kind.

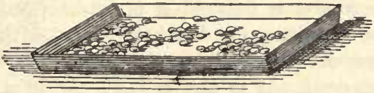
Tell that both parts are composed of fibres which we call *silk,* and are the product of the caterpillar of the silk-worm moth.

Cocoons.

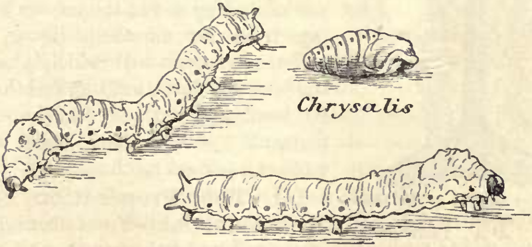
2. Give the history of the cocoon, illustrating by diagrams. The female moth lays a number of eggs—from 250 to 400—on the leaves which are to form the food of the grub when hatched. When the grub leaves the egg it is about ¼ in. long, and looks like a small black worm.

Female Moth.

In about eight days after this it moults and assumes a grayish colour. It continues to feed for the next five days and then casts its skin a second time, and after another five days it moults a third time, and after the same period it casts its skin for the last time in the caterpillar state. The creature is now about one inch and a half or two inches long.

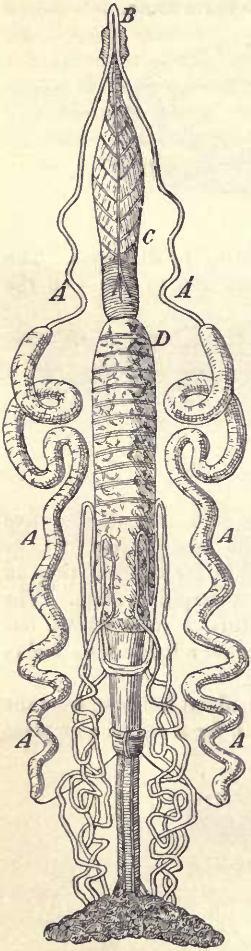


Eggs of Silkworm.



Silkworms.

In about ten days from the last moulting the caterpillar begins to search for a convenient place for forming its cocoon, and mounts upon any branches or twigs that are put in its way for this purpose. The substance of which the silk is composed is secreted in the form of a fine yellow transparent gum in two separate vessels situated in its body. The silk is drawn through two very small orifices placed just beneath the jaws and close to each other.



Secreting Organs of the Silk-worm Caterpillar.—A A, Silk secretors. A' A', Their excretory ducts. B, The spinneret. C, Throat. D, Stomach.

When a convenient spot has been found the creature begins its labour by spinning thin and irregular threads, which are intended to support its future dwelling.

During the first day the insect forms upon these a loose structure of an oval shape: this is called *floss silk*, and within this covering in the three following days it forms the firm yellow ball which is the cocoon proper.

When the insect has finished its labour of spinning it smears the internal surface of the cocoon with gum. During the operation of spinning the caterpillar gradually changes its form, and by the time the cocoon is finished it is transformed into an oblong roundish ball covered with a smooth shelly skin, and to all appearance dead. It is now called a *chrysalis.* See picture on preceding page.

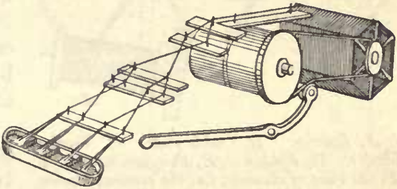
If left alone, in about nine or ten days the chrysalis changes into a moth, and works its way out of the cocoon by ejecting from its mouth a liquor, which moistens the gum with which it had lined the interior of its dwelling, and then with its head and hooked feet loosens the filaments, pushes them aside, and so escapes a perfect moth.

III. The Preparation of the Raw Material.—From a consideration of the nature of the cocoon, and comparing it with a piece of raw silk, children will naturally conclude that several operations will be necessary to bring the former into the state of the latter. Let them suggest what they think would be done, giving what is not known, and illustrating when it is possible to do so; and thus work out:

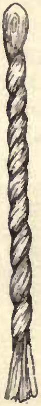
1. *The Sorting of the Cocoons.*—A number of the best are reserved for hatching, the rest are subjected to a certain amount of heat so as to kill the chrysalis. They are then carefully examined and sorted, all imperfectly formed cocoons being excluded.

2. *The Separation of the Floss.*—This is done by opening the flossy covering at one end and carefully pushing out the cocoon.

3. *Reeling.*—From a consideration of the fact that the caterpillar commenced winding the cocoon from the outside, proceeding towards the inside, the children will see that if the outer end can be found the whole can be unwound without entangling the thread. The unwinding of a ball of twine from the inside, from which point it was commenced, will make the matter clear. Then tell how the unwinding of the silk is effected.



Reeling from the Cocoon.



Slip (*Bengal*).

The natural gum is softened by immersing the cocoon in warm water: the ends of four or five or more threads are found, twisted together, and wound on reel. Each cocoon will yield from 300 to 500 yards of silk. When the end of the thread is nearly reached, it is broken off and new ones joined on.

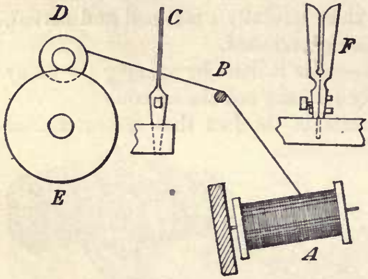
Hank (*Italy*).

The reeled silk is made up into *hanks* or *slips*, and a number of these are tied together and form what is called a *book*. In this state it is imported into England under the name of *raw silk*, and purchased by silk merchants, who sell it to the *throwsters* or spinners.

IV. The Processes of preparing the Raw Silk for the Loom.—By examining the raw silk and comparing it with some ready for use, children will see that the latter is much more even than the former. Tell how the change has been effected, illustrating the processes where it is possible to do so. Thus work out the following:

1. *Winding.*—Each hank is untied, extended upon a light six-sided reel called a *swift*, and from this it is wound on a bobbin.

2. *Cleaning.*—When the bobbins have been filled they are removed to the cleaning or picking machine. Here the thread is wound on another bobbin passing over a rod, and then between two very fine steel blades so adjusted that any irregularity in the thread will be taken off. This is a very delicate and important operation.



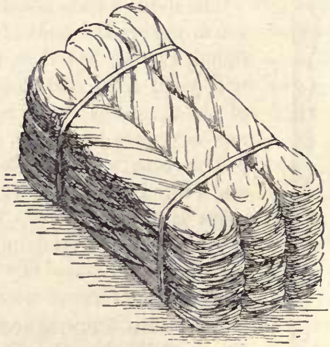
A, Bobbin. B, Guide rod. C, Vertical blades. D, Bobbin. E, Friction wheel. F, Front view of cleaner, i.e. the vertical blades.

In this form the silk is called *dumb singles*, because being in the gum it does not show up its lustre.

3. *Spinning*—In this process the single threads are twisted more or less according to the use to which the threads are to be put. If for the long threads, or warp, about sixteen turns to an inch are put in. Silk so prepared is called *organzine.* If for the cross threads, or weft, fewer turns are given. Silk so prepared is called *tram.*

4. *Doubling.*—In this process two or more threads are united so as to form one. The united threads, or *thrown silk* as it is sometimes called, is again taken to the spinning frame, and if for organzine are twisted about eight turns an inch, but in the opposite direction to the first twist. When tram is required it is twisted four times to an inch.

5. *Reeling.*—In this process the thrown silk is wound into *skeins* generally of 1000 yards each. If one skein weighs $\frac{1}{4}$ oz. = 4 dr., it is called 4-*dram silk.* One pound of such silk would measure a little over thirty-seven miles.



A Book of Silk (*China*).

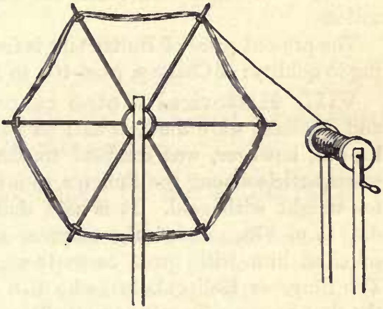
The skeins are carefully sorted, gathered into hanks, arranged into bundles, and pressed. In this state the silk is sold to to the weaver.

V. Preparation of Spun Silk.—Spun silk is the produce of the floss and waste of the cocoons. It is prepared for use in the following way:

1. The materials are boiled to get rid of the gum. When it leaves the boiler it is lustrous but tangled.

2. It is taken to the *breaker*, a machine which tears, breaks, and disentangles the fibrous mass. By this means it is reduced to lengths from 12 in. downwards.

3. The fibres are now combed, drawn, and spun much in the same way as woollen yarn.



Reeling from the Hank.

VI. Localities of the Silk Manufactures in England:

Broad Silks. Spitalfields in London, Manchester, Macclesfield, also Glasgow and Paisley, and Dublin.

Ribbons. Spitalfields, Coventry, Macclesfield, and Derby.

Handkerchiefs. Manchester, Macclesfield, also Paisley and Glasgow.

Hose and Gloves. Nottingham.

Crapes. Norwich, Colchester, and Frome.

VII. Silk-producing Countries, and Quantities imported.—The following table shows the quantity of silk imported into England in 1891 from the principal producing countries:—

	Silk.		Waste.
China,	1,277,061 lbs.	......	4,827,648 lbs.
Japan,	167,717 ,,	......	100,240 ,,
France,	292,711 ,,	......	617,680 ,,
Italy,	64,072 ,,	......	
Turkey,	30,381 ,,	......	
East Indies and Hong Kong,	575,560 ,,	......	2,629,424 ,,
Europe, thrown,	581,867 ,,		

The following calculation will interest the children. On the average it takes from 11 to 12 lbs. of cocoons to obtain 1 lb. of reeled silk; and as it takes from 240 to 250 cocoons to weigh 1 lb., the number of cocoons necessary to produce 1 lb. of silk may be reckoned to be 2800. Taking, therefore, the quantity of silk imported from

China alone, it required the astounding number of 8,864,620,800 silk-worms.

Again, cocoons may each yield from 300 to 500 yards of silk; consequently, the pound of silk filament, as produced by the worm, would, if stretched out, reach the amazing length of 500 to 1000 miles.

The present price of Italian silk is from 22*s.* to 28*s.* a pound according to quality; of Chinese, from 10*s.* to 16*s.*; and of Indian, 11*s.* to 15*s.*

VIII. Historical Notes respecting Silk.—The Chinese and Persians were the first nations who had any knowledge of silk; its use, however, was confined to the rich. It was an extremely scarce article among the Romans, so much so, that it was sold weight for weight with gold. It is said that the Emperor Aurelian, who died A.D. 275, refused the empress a suit of silk, for which she solicited him with great earnestness, on account of its dearness. The Emperor Heliogabulus, who died A.D. 220, is said to have been the first person who wore an all-silk garment.

Silk-worms were first introduced into Europe from Persia, in the reign of the Emperor Justinian, A.D. 527, by two Persian monks, who brought to Rome a number of eggs inclosed in a hollow cane. These eggs were hatched and the caterpillars fed on the leaves of the wild mulberry-trees. Vast numbers of these insects were soon reared in different parts of Greece, and manufactures set up at Athens and Corinth.

About the year 1130, Roger II., King of Sicily, established silk manufactories in different parts of his kingdom. In 1521 the French, being supplied with workmen from Milan, commenced the silk manufacture. The raw silk, however, was obtained from Italy, and it was some years later before silk was produced in France.

James I. of England endeavoured to introduce the silk-worm into this country, but without success. In 1620 the manufacture of broad silk was introduced, and by the year 1629 the silk manufacture had become so considerable in London that the silk-throwsters of the city were incorporated as a company, and in the year 1661 this company employed 40,000 persons.

On the revocation of the Edict of Nantes in 1685, a number of French refugees settled in London and established the silk manufactures of Spitalfields.

In 1718 Sir Thomas Lombe visited Italy to inspect the machinery used there in the manufacture of silken goods. On his return he established extensive mills at Derby. The trade afterwards extended to Macclesfield and other places.

For some years past the manufacture of silk goods has declined in this country. Thus, while in 1874 there were 818 factories engaged in the trade, employing 45,559 persons; at the close of 1891 there were but 623 factories, employing 44,277 persons. The total quantity of raw silk, waste, and thrown silk imported into this country in 1891 was 11,702,748 lbs.

Lesson 45.—LEATHER.

In this lesson we shall first speak of leather as used in the making of our boots and shoes. This is of two sorts—

First—Leather for the Soles, or Rough Leather.

I. Qualities of Leather.—Provide several specimens of shoe leather, take that which is used for the soles. Let the children say what they know of its source—prepared from the skins of animals—this from the skin of the bullock, so an animal substance.

Specimen to be examined and its qualities discovered. The sides of the leather differ in appearance. The upper side is very smooth and somewhat shiny; the under side dull and less smooth. By comparing it with a piece of metal the same size and thickness, children discover that it is much lighter.

Let a child take the leather in his hand and say what he can do with it. Bend it easily—flexible; when bent does not crack—tough.

Pour some water on the leather, it does not run through—is waterproof—impervious.

Refer to the time which it takes to wear out the soles of our shoes. Hence said to be durable. It is the last four qualities which render leather so adapted for making boots and shoes.

Place a piece in the flame of the candle; children say what they observe. It does not burn with a flame, but frizzles up and gives out an unpleasant odour.

Tell that, when wet leather is dried before the fire and is made very hot, it gets hard and cracks. On this account wet shoes ought to be dried gradually, never being placed near the fire.

II. The Preparation of the Hides for Tanning.—If possible provide a specimen of raw hide, and by comparing this with the leather children will see the necessity for some operations to convert the skin into leather. As each is suggested, explain and illustrate how it is done, and so work out the following processes, which should be tabulated, as the lesson proceeds.

1. *Softening and Cleansing the Dried Hides.*—Tell children that many hides are brought from South America and other countries, and to prevent the skins from becoming putrid they are salted and dried. In this state they could not be tanned. Children suggest how they may be softened. By the use of water. Hides soaked in water for some time and rubbed with a wooden instrument called a *stock*. By these means the hides are brought back as near as possible to the condition of fresh hides.

2. *The Removal of the Hair.*—Let children suggest modes, either cutting, shaving, or plucking. But if either of two former, the roots will be left in. The latter mode would take up too much time.

Removing the Hair.

Call attention to the diagram of a section of skin. The hairs are developed in the epidermis, and close to the fat-glands. If the roots could be loosened the hairs might easily be removed. Tell how this is done. Slaked lime is slightly soluble in water. So a solution of this is made, called *milk of lime*, and in this the hides are put for several days. Each day they are turned several times so as to expose every part of the hide to the action of the lime.

The lime water causes the hardened cells of the epidermis to swell up and soften the cells beneath; also to loosen and dissolve the hair-sheaths. These can now easily be removed by scraping the hide with a blunt knife. Show picture. This process is called *unhairing*. The lime, in addition to loosening the hairs, causes the hides to become plump and swollen, and also affects the substance of the true skin in a manner which fits it for the after process of tanning.

3. *Fleshing.*—When the skin is taken off the beast small portions of fat and flesh adhere, and as these will not tan they must be got rid of, and this is done by scraping and paring the inner side of the skin with a sharp knife.

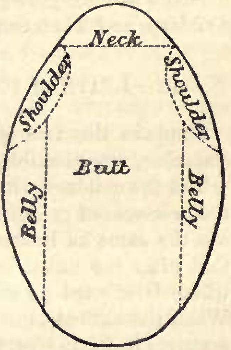
4. *Rounding.*—Show diagram of whole hide. Children will see that all parts would not be equally useful for the purposes to which leather is put. Which part would be the most valuable? Yes; the back. So the hide is cut up into pieces as shown in diagram, and the *butt* is the part which is reserved for tanning. The other parts are called *offal*.

5. *Cleansing and Tanning.*—To remove the lime and dirt which

may be on the hides they are put into a weak solution of acid and water; this not only cleanses the hide, but causes it to become plump.

When clean the butts are placed in pits with a solution of oak-bark and water called *ooze;* first, in a weak ooze, then in stronger from day to day for periods varying from one to twelve months. They are next put into much stronger ooze, and changed constantly for another period varying from five to ten weeks. By this time the skin is thoroughly tanned, or turned into leather.

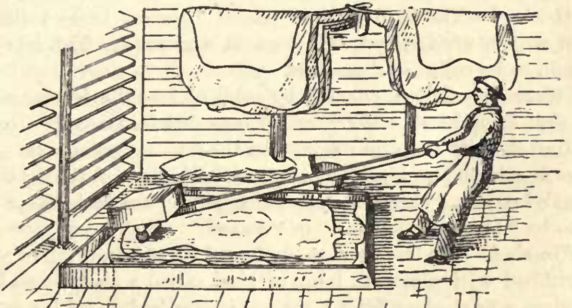
The change in the nature of the skin is brought about by the action of the *tannin* of the oak-bark on the gelatine of the skin, and so causing all traces of the animal substance to disappear. In proportion as this change is thoroughly or only partially effected is the quality of the leather.



Method of dividing the Hide.

6. *Cleaning and Drying.*—The leather as bought is dry, but when it leaves the tan-pit it is wet; it has therefore to be dried, and this is done in the following way:—

When the hide is taken out of the pit it is first washed and then hung up in lofts and exposed to the action of the air Once or twice during the drying the butt is placed upon a bench and struck or smoothed with a square bar, the surface being occasionally wetted.



Finishing Hides.

The effect of this operation is to produce on the surface a yellow deposit called *bloom* or *pitching.*

7. *Finishing.*—When the drying is sufficiently advanced the hide is submitted to the action of a brass roller about nine inches wide loaded with heavy weights from fifteen to thirty cwts. This is called *finishing,* and when complete the hide is fit for the market.

Second—LEATHER FOR THE UPPERS, OR DRESSED LEATHER.

Compare the two specimens. Leather for the uppers thinner, smoother, more flexible, and blackened on the upper side.

Tell the children what skins are used for this purpose, and that all the processes of preparing the skin for tanning and the tanning itself are the same as in the case of the sole leather, with the exception that after the unhairing it undergoes a process called *bating,* and which is effected by working the hide in a solution of dog's dung. When the skin is tanned and dried it is taken to the *currier,* who prepares it for the particular use to which it is to be put. The following are the processes by which it is prepared:—

1. *Reduced to a proper Thickness.*—This is done by shaving the under side with a sharp knife. Now said to be *shaved.*

2. *Made Smooth.*—The skin is now rubbed with oil and then stretched on a frame. This process takes out all the wrinkles and gives the skin an even smooth surface. It is now said to be *seasoned and set.*

3. *Grained.*—The skin is next passed between brass rollers, or beaten with a wooden instrument called a *pommel.* The leather is now said to be *rolled and grained.*

4. *Colouring.*—This is effected by rubbing into the leather a mixture of oil, lamp-black, and tallow. If intended for the upper leathers of ladies' shoes the mixture is put on the hair or grain side. Such leather is said to be "black on the grain." If intended for the uppers of men's boots and shoes the mixture is put on the flesh side, and is said to be "black on the flesh" or "waxed."

5. *Finished.*—The leather thus blackened is next sized, tallowed, and well rubbed with a smooth lump of glass called a *slicker,* and lastly it receives a final gloss from a little thin size laid on with a sponge. The leather is now ready for the shoemaker.

Different Kinds of Leather. (THIN LEATHER.)

1. *Kinds of Thin Leather or Skins.*—Let the children mention the different kinds of leather which they may have seen, and the uses to which they are put. Show as many as possible. Thus we have:—

White and dyed Leather for gloves. *Morocco* of various colours and qualities for coach lining, book-binding, pocket-books, &c. *Roan* for slippers, &c. Very thin leather called *skiver*, used for hat-linings and many other purposes. *Shammy* or *chamois* or wash-leather.

Tell the children that these various kinds of leather are prepared from the skins of small animals, and are spoken of as *skins*, not *hides*.

2. *Their Preparation.*—Morocco is prepared from the skins of the goat. They are unhaired and fleshed much in the same way as hides; but they are tanned with *sumach*. They are afterwards dried and prepared by the currier. For the commoner kinds of morocco sheep-skins are used. Before the skin is tanned it is split into two distinct pieces, made in fact into two. This is effected by means of a very beautiful machine called the "skin-splitting machine." The upper or grain side is tanned for the morocco, and the under or flesh side is used for wash-leather.

The white and dyed leathers for gloves are prepared from the skins of kids, sheep, or lambs. They are not, however, tanned, but preserved by means of alum and salt, or *tawed*, as it is termed. After being subjected to the action of alum and salt the skins are dried. They are then white and somewhat brittle. They are next *dressed* by being rubbed with a mixture of wheat-flour and the yolks of eggs, and lastly finished by being washed in pure water, stretched upon a rounded iron plate, and smoothed with a hot iron. The inner portion of sheep-skins used for wash or shammy leather is neither tanned nor tawed, but prepared by being dressed in oil.

The split skins are spread upon a table, sprinkled with oil, and folded up in balls of four each. They are then beaten by a number of heavy wooden hammers in the *pulling stocks*. Next exposed to the air, and oiled and pulled again. They are next hung up in a warm room, then scraped with a blunt knife, and scoured in a warm potash lye to remove the superfluous oil. They are afterwards washed in clean water, gently dried, smoothed, and made supple by passing them between rollers.

LESSON 46.—FUR.

The objects required for this lesson are, a piece of sable fur, several different kinds of furs, and pictures of the chief fur-giving animals.

I. Introduction.—When the cold days of winter come people wrap themselves up in thick coats, &c., to keep themselves warm. Girls bring out their muffs and capes. These articles of clothing are made of fur. This the subject of the lesson.

II. Qualities and Use of Fur.—Children examine a piece of fur, and so discover that it has two parts—the skin and the hair. The skin is rather stiff, and very tough. The hairs are placed very close together, are soft, flexible, and pointed.

From a more careful examination of the fur it will be found that the hairy covering consists of two portions—the fur proper, which is soft, short, curly, and barbed, and long, straight, smooth, and stiff hairs, which are placed between the barbed filaments of the fur, and prevent them from matting or felting together, as they otherwise would. Impress upon the children the wisdom of this arrangement. These long hairs are called the *overhair:* they give additional beauty and value to the fur.

Require a child to put the fur against his face and say what he perceives. It feels warm. Let the child put one hand on the fur and the other on the face of another child. Explain the difference in the feeling. The flesh is really warm, the fur is not, although it appears to be. The reason is, that the blood which is flowing through the veins is warm. The warmth of the blood is always passing away in a manner which will be taught them when they are in a higher Standard. The fur has the power to stop the warmth of the body from passing away, and so keeps the person from feeling cold. And this is why it is used for muffs and other articles of dress.

The people who live in very cold countries, as Norway, Sweden, and Russia, wear dresses made entirely of fur, or they have the whole of the dress they wear lined with fur. In this country fur is only worn in the winter, and then partly for ornament as well as for warmth. Ladies have fur trimmings on their cloaks and dresses.

In the same way that fur keeps us warm it keeps the animals warm that are covered with it. In the winter, when the weather is very cold, the fur is thicker than it is in the summer. Question as to whether any of them have stroked a cat in the summer. When they did so they found some of the fur come off in their hand. Of course it could not have come off unless it had been loosened at the roots. And this is what takes place in the summer, and so the fur is partly shed at that time of the year. Before the winter comes more hairs grow, and then the fur is thicker again. They see, then, that the winter coat of the animals will be the best to take for fur, especially if the animals live in cold countries.

III. The Animals whose Skins are used as Fur.—Show pictures of some of the animals. Thus there is the *silver* *fox*. It is covered with dark fur, with some long hairs tipped with white. It is very beautiful and very valuable. As much as £20 is sometimes given for one skin. This fur is generally used for trimming, and when cut into strips about half an inch wide is often sold for £4 a yard. Another animal whose skin is very much prized for its fur is the *sea otter*. As much as £60 has been paid for one skin. The colour of the fur varies from a beautiful brown to jet black. It is very fine, soft, and glossy. Another animal is the *Russian sable*, whose skin gives us the fur examined at this lesson. This fur is not nearly so valuable as the others. A good skin may be bought for £2. Another pretty little creature, with a snow-white covering in all parts but the tip of the tail, which is black, is the *stoat*, but the white fur is called *ermine*. In the summer the creature is covered with a reddish-brown fur, which turns into white when the winter comes. It is a very valuable fur, and is used for the robes of kings and nobles. The judges of our land have their robes trimmed with ermine.

Many other kinds of fur are used. The following are the principal:—

Marten fur, which is of a rich, dark-brown olive colour.

Fiery-fox fur, brought chiefly from the north-eastern parts of Asia. It is valued on account of its brilliant colour and for its fineness.

Red-fox fur, differing in some respects from the fiery-fox. It is much used by the Chinese for trimmings, linings, and robes.

Nutria fur is obtained from the animal called the *coypou*, a native of South America. This fur is used as a substitute for beaver.

Seal fur is obtained from the seals frequenting the coasts of cold countries, the best being found in the Southern Ocean.

Beaver fur. This fur was once much in request for the manufacture of hats, but it is not now much used for that purpose.

The fur of various other animals is valued either for its warmth or its beauty, such as that of the *bear*, *racoon*, *badger*, *minx*, *lynx*, *musquash* or *musk-rat*, *rabbit*, *hare*, *squirrel*, and *chinchilla*.

IV. The Preparation of Fur for Use.—Tell that for manufacturing purposes furs are placed into two classes, and spoken of as *felted* and *dressed*.

1. *Felted Furs.*—Felted furs are those in which the hairs or filaments are made so to interlace or entangle as to form a kind of cloth, which is called *felt*. The furs used for this purpose are those of the beaver, nutria, hare, and rabbit.

By comparing a piece of felted fur with a piece of the skin children will see that the fur must have been removed from the skin.

Let them suggest how this might have been done—pulled or cut. Tell them that both plans are used.

Have the piece of hare fur carefully observed. Children will see that the fur consists of two kinds of hairs—long and short. Tell that it is the short hairs which are used for felting, and describe how they are removed from the skin, or *pelt* as it is called.

In some cases the long hairs are cut off by a pair of shears, in others they are pulled off by hand. The short hairs are cut off by means of a very sharp blade fixed in a machine.

As the fur is cut off it falls into a kind of apron, and is then carried to a blowing machine. This machine separates the fur into three or four qualities. How this is accomplished may be questioned out by referring to the action of wind on any light substances on which it falls. The children will thus see that the lightest—which are the most valuable—will be blown to the furthest distance, leaving the heavier and coarser to be deposited sooner. The different sorts are then taken to the felter.

2. *Dressed Furs.*—These are the furs which are prepared by the furrier, and are used for making muffs, capes, and fur trimmings to garments.

Let children examine a piece, when they will see that for these purposes the fur is not separated from the pelt. The two are used together, and the pelt is converted into a kind of leather.

Tell how the skins are prepared. The fur hunter having taken the skin off the animal, dries it with very great care. In the dried state the skins are brought to England.

Children can suggest what must be done to the skin—cleansed. Tell how. Steeped and scoured in a bath of bran, alum, and salt. This removes the greasiness from the pelts, and converts them into a kind of tawed or kid leather. The skins are next placed in a bath of soap and soda to remove oiliness from the fur. They are then thoroughly washed and dried, and are now ready to be made up into articles of dress.

V. The Care of Fur.—As fur is an expensive article it should be carefully preserved. Two things will spoil it—damp and the moth. To guard against the first never put the article away while wet. If it has been exposed to the rain it should be dried before the fire, care being taken not to hold it too close. To preserve it from the moth, before putting it away after winter wear beat it with a thin cane, comb it in the direction of the hair, and then pack it up closely in brown paper or linen. A lump of camphor may be placed in the parcel.

VI. The Fur Trade.—The skins before they are prepared are called *peltry*. The number imported into the United Kingdom during the year 1891 was 39,841,892, and the declared value in the raw state was £1,399,652.

The following is a summary of the estimated annual production, sources, and value of the furs of commerce, gathered from Spons' *Encyclopædia of Industrial Arts:*—

Name of Skin.	Number.	Size.	Value.	Imported from
Badger,	50,000	2 ft. by 3 ft.	3/6 to 7/	Eur., Asia, Amer.
Bear, Black, Brown, and White,	19,000	6 ft. by 3 ft.	64/ to 95/ 400/	Eur., Asia, Amer. Polar Regions.
Beaver,	220,000	2 ft. by 3 ft.	42/	N.Am., Labrador.
Cat,	1,010,000		4/ to 8/	Holland.
Chinchilla,	100,000	8 in. by 12 in.	13/6 to 16/	Chili and Peru.
Ermine or Stoat,	400,000	4 in. by 10 in.	6/	Eur., Asia.
Fitch or Polecat,	600,000	5 in. by 15 in.	6/	Europe.
Fox, Silver or Black,	2,000	2 ft. by 4 ft.	800/	Amer., Asia.
Fox, Cross,	10,000	,, ,,	140/	America.
Fox, Blue,	7,000	,, ,,	80/	,,
Fox, Arctic,	75,000	,, ,,	18/	,,
Fox, Grey,	30,000	,, ,,	8/	,,
Fox, Kitt,	40,000	Smallest Fox,	3/	,,
Fox, Red or Common,	360,000	2 ft. by 4 ft.	20/	
Hamster or Rat,	200,000	3 in. by 5 in.	Cheap.	Europe.
Hare,	4,500,000		5*d.* to 12*d.*	Europe, Asia.
Lynx,	50,000	2 ft. by 3½ ft.	21/	Europe, Asia.
Marten or Sable,	130,000	5 in. by 15 in.	110/	America.
Marten, True Russ. Sable,	100,000	,, ,,	5/ to 600/	America.
Mink,	255,000	6 in. by 18 in.	12/ to 40/	Amer., Russ.
Monkey,	40,000		2/6	Africa.
Musk Rat or Musquash,	3,100,000	8 in. by 12 in.	2/	America, Asia.
Nutria,	3,000,000		2/ a lb.	South America.
Opossum,	250,000		3/ each.	South America.
Otter,	40,000	2 ft. by 5 ft.	56/	All N. countries.
Sea Otter,	5,000	2 ft. by 6 ft.	Some fine samples sold for £100.	North Pacific.
Rabbit,	5,000,000		5/6 a doz.	Europe.
Raccoon,	500,000	1 ft. by 2 ft.	40/	America.
Seal Fur,	200,000	2½ ft. by 5 ft.	£20	Pacific.
Squirrel,	6,000,000	3 in. by 6 in.		Siberia.

SECTION IV.

Animal and Vegetable Substances used in Manufactures or Domestic Life.

LESSON 47.—CANDLES.

The objects required for this lesson are, specimens of the various candles in use, a lump of tallow, a wick, the various substances used for candles, and a picture of candle-making.

I. Introduction.—Question out the fact that during some parts of the year the daylight is not long enough to enable man to do all his work, and so he has to get light in some other way. The light so produced is called *artificial light.*

Let the children mention the different modes of obtaining artificial light, and so bring out:

1. In the streets, shops, and in dwelling-houses gas is burnt.

2. In some of the principal thoroughfares, railway-stations, and large buildings in London and other large towns, a very powerful light, called the *electric light,* is now used.

3. Those people who live in houses, or rooms in which the gas is not laid on, either use lamps or candles. The present lesson will be on *candles.*

II. The Parts and Qualities of a Candle.—Use an ordinary tallow candle—a mould. Require the children to observe and describe the object as a whole.

A candle is cylindrical; it has one flat face, one curved, and one conical.

1. *Parts of a Candle.*—It consists of two parts, the body and the wick. The wick passes all down through the middle of the tallow; it is made of cotton, is white, smooth, tough, fibrous, and inflammable. The body is formed of tallow placed round the wick; it is white, smooth, rather soft, greasy, easily melted, and combustible.

2. *How it is used.*—Question out what is done when a candle is used. Light one, call attention to what takes place, and so work out:

When a candle is being used it is placed in a stand called a *candlestick.* A flame is brought to the end of the wick, when it begins to burn with a flame. The heat from the burning wick melts the tallow, which then runs up the wick, becomes itself heated, and is burnt in the flame. While there is any tallow left the candle continues to burn.

Note.—If the children are at all advanced lead them to see what takes place in the operation of burning.

Place a lighted candle in a glass tube so as to keep away the draught. A lamp glass will do. Call attention to what may be observed.

After the wick has been lighted a short time, a cup is formed. This is caused by the air passing up and cooling all the outer sides of the tallow so as to keep the edge cooler than the part within. The tallow near the wick is kept melted by the flame which runs down the wick as far as it can go before being extinguished by the melted fat. The melted tallow, which is the fuel in a liquid state, passes up the wick by capillary attraction, and as it reaches the flame is made hot—hot enough to turn it into gas. This gas supplies the flame with fresh material for combustion.

III. Different kinds of Candles, and their relative Value:

1. Kinds of Candles.—Having provided the necessary specimens let children name them as held up; so work out that the kinds of candles used are:

Rushlights.—These are thin candles having rush wicks; hence their name.

Common Dips.—So named because of the manner in which they are made.

Mould Candles.—So called because they are made by casting. There are several kinds of mould candles; some are made of tallow; some of palm-oil mixed with other kinds of fat. These are often spoken of as *composite candles.* Some are made of a substance called paraffin, which is obtained from a particular kind of coal; and some are made of bees'-wax: these are called *wax candles.*

2. The Relative Value of each Kind.—During the course of the lesson place side by side and light a rushlight, a common dip, a composite, a paraffin, and if possible a wax candle. Let them be all of the same length when they are lighted. Supposing them to have been burning some time, say a quarter of an hour, call the attention of the children to the state of each.

First—respecting the Wicks:

a. The rush is very thick in comparison with the whole thickness of the tallow of the candle.

b. The wick of the common dip is also very thick in comparison with the size of the whole candle.

c. The wicks of the composite and wax are smooth and thin in comparison with the thickness of the whole candles.

Second—respecting the manner of the Burning of the Wicks:

a. The rush remains charred above the flame. It is very brittle, so that when touched it breaks off.

b. The cotton wick of the dip also remains at the top charred; it does not fall off, so requires to be *snuffed.*

c. The thin wick of the composite, paraffin, and wax bends over, and the end projects to the outer edge of the flame, and is consumed as the fat burns away. On this account such wicks do not require to be snuffed.

Third—respecting the Flames:

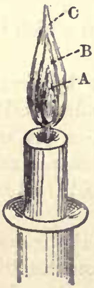
a. That of the rushlight is small and rather red.

b. That of the common dip is fairly large, but is rather red.

c. Those of the paraffin and wax are rather small, but are white and bright.

From these points the children will be able to conclude that the self-snuffing wicks are the most convenient, and that for the purposes which require a clear steady light the composite is better than the dip, the paraffin better than the ordinary composite, and the wax the best of all.

Tell the price of each per pound, and the number of hours each will burn, and so lead the children to conclude which is the most economical to use when a good light is required.



C, Cone of combustion. B, Cone of partial combustion. A, Cone of non-combustion.

If the children are old enough direct their attention to the character of the flame, and work out the following points:

Shape.—Conical; this caused by the pressure and ascent of the heated air.

Character.—Hollow; outer part called the *cone of perfect combustion.* Inner part dark. Show why. Insert a thin tube so that the end is exactly in the middle of the hollow. Apply a light to the other end. What do they observe? A small flame. Explain how this is. The inner portion of the flame contains vapour-gas, and this cannot be burnt until it comes in contact with the air, and this it cannot while it is in the centre. This dark part of the flame called the *cone of non-combustion.*

Direct children's attention to the cone of combustion. More luminous on the inner portion. Explain why. The material of which the body is composed contains carbon and hydrogen. The latter requires less oxygen to inflame it than carbon does, and when inflamed gives out great heat, and so makes the carbon white hot.

IV. The Manufacture of Candles.—Show the raw materials of the candles: tallow, palm-oil, paraffin, wax for body, rush and cotton for wicks. The children to suggest the obvious operations, namely, making the wicks, the preparation of the tallow or other materials, and the forming of the candles.

1. THE PREPARATION OF THE WICKS:

a. Rush.—The common soft rush found growing in moist pastures, beside streams and ditches. Abundant in Lancashire, in the Fen country, and in Ireland. The rushes are cut in the summer months, laid for some time in water, then stripped of half the peel, bleached in the sun and dried. When dry they are bound in bundles and sent to the candle-maker, who cuts them into proper lengths and makes a loop by which they can be suspended on a rod ready for the dipping.

b. Cotton Wicks for Dips.—Material used loosely spun cotton. If for common dips the cotton is only slightly twisted; the threads are then covered with melted fat to keep them together. If for snuffless wicks the cotton is plaited, bleached, steeped in a solution of borax, and then dried. The borax retards combustion and causes the ash to be destroyed when it comes in contact with the air.

2. THE PREPARATION OF THE MATERIALS.—Let the children compare a common dip with one of the best candles—say one of Price's palmitines—of the same size, when they will see that the former is softer, more greasy, and not so white, and, as they can see by looking at those which are burning, the dip does not give as much light as the palmitine or the wax. Tell the children that this is the result of the difference in the nature of the materials of which the candles are composed. This difference will now be explained.

a. Tallow, i.e. beef or mutton fat; these, and indeed all kinds of fatty bodies, consist of three materials, namely, stearine, oleine, and glycerine: the first mentioned is the hardest, and the last the softest. In proportion, therefore, as the two softer are got rid of will be the hardness of the candle.

The separation of the glycerine from the fat is thus effected. The tallow is placed in a large wooden vessel with 16 per cent of good slaked lime, made into a thin cream with water. The vessel is now tightly closed, steam is introduced from a pipe below, and the contents are boiled for four hours. During the boiling the mixture is kept in motion.

During the boiling the lime decomposes the tallow, the glycerine is set free, and lime joins itself to the stearine and oleine, and forms a solid mass at the bottom of the vessel. When cool it is cut out. The separation of the stearine from the oleine is next effected by the following processes.

They are first boiled with strong sulphuric acid—four parts of acid for every three parts of lime previously used. The sulphuric acid joins itself to the lime and forms sulphate of lime, which falls to the bottom, and the fat rises to the surface.

When the mass is cool the fat is removed and washed.

The clean fat is next melted, run into dishes or troughs made of tin, kept at an equal temperature (68° to 86° F.) for two or three days, by the end of which time it assumes a crystalline structure.

This material is now cut into shreds, powdered, placed in canvas bags, and submitted to great pressure in a hydraulic press. The pressure causes the oleine to flow out, leaving the stearine in the bags in the form of cakes. These are next ground into a powder, and again heated and submitted to pressure, by which means the whole of the oleine is got rid of and pure stearine remains.

The cakes are next melted by steam, a little wax being sometimes added to render the stearine less crystalline, and so render it more fitted for candle-making.

b. Palm-oil.—This substance is obtained from the fruit of the oil palm, which grows in various parts of Africa, especially on the west coast. The fruit resembles the stone of the date, and when ripe contains a large quantity of oil—one gallon of nuts producing a quart of oil.

After the nuts are gathered they are allowed to ferment, are then coarsely pounded in hollow cylinders, by which the oily matter is separated from the fruit, and boiled in water. The oil gradually collects on the surface of the water, and when cool becomes a *solid substance* of a deep orange-yellow colour, with little or no taste, but having a rich perfume. It is put into casks and exported to England and other countries.

As the palm-oil contains the same constituents as tallow, it undergoes much the same treatment in order to remove the glycerine and obtain the pure stearine.

c. Paraffin.—This is a mineral substance, solid at the ordinary temperature of the air, hard, and white. It is obtained from coal-oil, one of the products of the distillation of certain kinds of coal.

The crude oil is black and rather thick. It contains, among other things, a solid substance which gradually crystallizes in it. These crystals are called *paraffin scales:* they contain about 20 per cent of impurities, consisting of blue oil, greasy oil, and other matters. These are removed by various distillations and other processes, and at last the pure paraffin is obtained.

d. Spermaceti.—This is an animal substance obtained from sperm-oil, which is found in the head and other parts of the sperm whale. It is thus procured. The crude sperm-oil is placed in a reservoir, at the bottom of which are a number of pipes leading into long bags lined with linen, and temporarily closed by tying cords round the mouths. The pressure exerted by the material in the reservoir forces a large proportion of the oil through the sacking, leaving behind the solid or *head matter* as a dingy brown mass.

This so-called crude or *bagged* sperm is afterwards pressed several times, boiled with caustic soda, and when purified, it is cast into blocks and is ready for the candle-maker.

e. Bees'-wax.—This is an animal substance, excreted in the form of scales on the under part of the abdomen of the working bees, and used in the construction of the cells of their combs. It is of a brownish or yellowish colour, and has a peculiar smell resembling honey. It is purified and rendered white by being melted in hot water, or by steam, in a vessel either of tinned copper or of wood. The melted wax is run into a wooden trough, having a row of small holes in its bottom. Under these holes are placed wooden cylinders with their lower portion surrounded with cold water. The melted wax running through the holes falls on the cylinders, and as these revolve they carry the wax in the form of thin ribbons into the water and thus it is rendered solid. The ribbons made in this way are then exposed to the bleaching action of the atmosphere and sunlight, being frequently moistened and turned over during the process. The wax is now perfectly white, and has neither taste nor smell. It is now formed into cakes and is ready for the candle-maker.

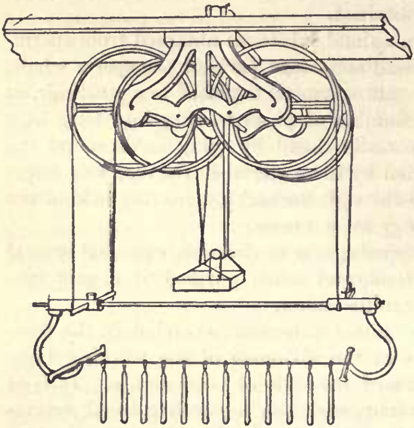
f. Ozokerite or *earth wax* is a kind of mineral paraffin. This substance has only of late years been used in this country for candles. It is prepared for use much in the same way as paraffin or palm-oil.

3. FORMING THE CANDLE:

a. Dips.—By allowing the children to compare a lump of tallow and a wick with the perfect candle, they will see the necessity of some plan by which to place the tallow round the wick. Let them suggest a plan. Give the following information:

A number of wicks are placed on a rod so arranged that there is a proper distance between each. A number of these rods are placed in a frame. The frame can be easily raised and lowered.

Under the frame there is a trough of melted tallow. The candle-maker stands in front of the trough, lowers the frame so as to bring the wicks into the melted grease, and thus each wick gets coated with tallow. The frame with the coated wicks is put away so that the melted grease may cool and thus set.


Dipping Frame.

Show children such a wick, when they will see the necessity for further dipping. Tell that the wicks are dipped and cooled again and again until of the proper thickness. The thickness is determined by the number of candles which are to weigh a pound; four, six, eight, ten, twelve, or more, as the case may be.

b. Moulds.—Let children compare a mould candle with a dip, they will see that the former is smoother, body more true in shape, and the top formed differently—the wick has no loop. Tell how this is brought about.

Mould made of metal and of the size and shape of the candle, the inside surface of mould very smooth, and the bottom part a little bigger than the top. A number of these moulds placed in a frame. The plaited wicks placed in the middle of the moulds and held there by a wire. The melted tallow poured into the frame fills up each mould and so forms a candle. When all full, the frame set on one side to cool. The excess of tallow is now removed from the top of the frame, the wires which hold the wicks removed; the frames turned up and the candles, which are a little larger at the bottom than at the top, fall out.

c. Wax Candles.—If possible provide a piece of a bees'-wax candle. Let a child examine the body and compare with mould. Same in form, but is made up of layers. Tell how such candles are made.

A number of wicks are hung on a circular frame; the top of each wick is covered with a metal cap. The frame is carried to a heater where the wax is melted. The frame is then turned slowly round and the candle-maker takes a vessel of melted wax, pours it first down one, and then the next, and so on until he has poured some down each wick. When cool enough he repeats the operation until the candle is of the required thickness.

Each candle is now rolled upon a fine stone slab, and so made perfectly smooth and cylindrical. The top is now moulded, the bottom cut off and trimmed, when the candle is finished.

Notwithstanding the extensive use of gas and oil for the purpose of domestic lighting, there is still a large demand for candles. In 1891 the importation of tallow and stearine was 1,371,201 cwts., valued at £1,772,268. In the same year the exportation of candles was 15,874,200 lbs., value £314,394.

LESSON 48.—SOAP.

I. Introduction.—Introduce the lesson by referring to the case of a boy who, while on his way to school in the morning, dirtied his hands by laying hold of the greasy handle of the railway carriage, and who tried to get the dirt off by rubbing his hands together in some clean water. Having failed in his efforts to make his hands clean, he was afterwards sent by his schoolmaster to wash them in the lavatory. He did so and thus got rid of all the dirt. The class to explain the cause of the difference. In the first washing he did not use any soap; in the second he did.

II. Why Soap will Cleanse.—Lead the children to see why the water alone would not cleanse the boy's hands. Take a child who has dirty greasy hands, and let them be washed before the class. Having provided the necessary things—a basin of clean water, a lump of soap, and a towel, question as to what must be done by the boy. He must rub the soap on his hands. He has done so; but as the soap is dry none has come off. What then must he do? Put his hands and the soap into the water and rub them together. Let him do this. What do they observe? Some of the soap has dissolved and formed a lather, which is slippery to the touch, or is soapy: it is white.

Let the class observe carefully what takes place while the boy rubs his dirty hands together. The clean white lather becomes dirty.

Question as to where the dirt has come from. The boy's hands. The soap has dissolved the grease and dirt, and so both will now mix with the water, which they would not do before.

The boy now to put his dirty soapy hands into the water and rub them together. The children will see that the lather is washed off, and while his hands are clean the water is dirty. From this they will see that soap is soluble in water, and that it also makes grease soluble, and that the grease and dirt, when soap is used, are mixable with water, and so both can be removed from dirty articles.

III. The Constituents of Soap, and how it is Made.—Tell the children that soap which, as they have seen, has the power of making grease soluble in water, is itself made of grease, tallow, suet, kitchen fat, palm, cocoa-nut, and other kinds of oil being used according to the kind of soap which is required. The grease, however, is mixed with what is termed an *alkaline* substance, as soda or potash, which when boiled with the grease turns it into soap. Illustrate the principle of soap-making in the following way:

Half fill a phial with oil. Make a strong solution of soda. Mix this with the oil and shake it well. Children will see that the oil changes colour, mixes with the soda, and becomes altered in its nature. Allow the mixture to rest, the altered oil will rise to the top, and the watery portion of the solution will be seen at the bottom. Take out some of the substance which is at the top and let the children feel it. It is not now greasy oil, but is like soap. Tell that the oil is said to be *saponified.*

Question as to what must be done to make this fit for use. The water must be drawn off, and the soapy material made solid. Let them suggest how this may be accomplished, and then tell how the operation is carried on in the actual manufacture of soap on a large scale.

A quantity of tallow, oil, or some other grease, is melted in an iron pan, and while it is in a melted state the soda or potash which has been dissolved in hot water and boiled with lime is put into the grease and boiled for four hours. The mixture of soda, sulphate of soda, and lime is called *caustic lye.* At the end of the four hours the lye has lost its power, and the fat has become partially turned into soap or saponified. The fire is now withdrawn and the mass allowed to cool. The separation of the lye is aided by throwing common salt into the mixture. By observing the saponified grease in the bottle the children will see that the partially formed soap will rise to the top of the spent lye.

Tell that the latter is now pumped out, a stronger lye added, and the whole is boiled as before and cooled. When cool the spent lye is again pumped out. The same operation is repeated five or six times, when the grease has become perfectly saponified or made into soap.

By comparing the material in this condition with the soap as purchased the children will see the necessity for some further operation:

First, it is much too *thin*. Let class suggest how thin liquids containing water may be thickened. By boiling, and this is what is done. Explain the operation. The material is first boiled in weak lye and then in strong, until most of the water has passed off in the form of steam. When the mass has assumed a proper consistency the fire is withdrawn and the soap allowed to cool. The longer the time the material is boiled the less will be the quantity of water which the soap will contain.

A further comparison of the material in this state with a lump of soap will lead the class to see the necessity for another operation. Must be rendered quite *solid* and *shaped*. Tell how this is accomplished. When the mass has lost water enough the fire is withdrawn and the soap allowed to cool. This takes two or three days or longer according to the quantity in the copper. When cool enough the soap is ladled out and put into frames. When quite cold it is a solid block. It is now taken out of the frames and cut into slabs and bars, put into boxes, and sold at so much a hundredweight.

IV. Kinds of Soap.—Provide several kinds of soap and arrange them into—

COMMON SOAPS, as *Curd* or *White Soap*. *Pale* or *yellow soap*, yellow colour caused by adding about one-third of its weight of rosin to the tallow while it is being boiled. *Mottled soap*, so called from the bluish-black marks which are found running through it. This mottled appearance in the best English curd-mottled soap is thus accounted for:—The lye formed of sulphate of soda contains a certain amount of iron; and to what is already there, some sulphate is often added. The contents of the pan are left to rest for half an hour; the under lye is drawn off; the mass is stirred so as to mingle the coloured parts. When properly mixed the soapy mass is scooped into moulds and allowed to cool very gradually—eight or ten days being required. In the process of cooling the colouring matter collects into veins, and thus when the soap is cut into bars it has the mottled appearance from which it gets its name. *Soft soap*, so called from the fact that it never assumes the solid form of other soaps. The principal ingredient in this kind of soap is fish or other oil, to which is added about one-fifth of the weight of tallow. The lye used is made of American potash. The tallow helps to give a proper consistency to the soap, and produces those white specks which characterize this kind of soap.

FANCY SOAPS, as *brown* and *white Windsor*, *honey*, *elder-flower*, and *glycerine soap*. These soaps, which are used only for washing the skin, are often scented with perfumes, and are spoken of as *scented soaps*.

V. Practical Lessons:

1. From a consideration of the fact that the saponified fat contains water, which can only be got rid of by boiling the material while still a liquid, the children will see that, in proportion as that process is properly carried on, will be the quantity of water which will be found in the finished soap. The best made soap will contain the least water, and will be the most economical.

Good curd soap should contain about 64 parts of its weight of saponified grease; 2 parts of soda, and 32 of water. Soap made from cocoa-nut oil generally contains one-third more water than that made of suet or tallow.

Newly-made soap contains more water than that which has been made for any length of time. The drier the soap the harder it is to the touch. Soap should be bought before it is wanted for use, cut into pieces, and laid in a dry place.

2. From a consideration of the fact that soap is soluble in water, the children will see the necessity of taking it out of the water after it has been used, otherwise it will dissolve, and thus be wasted.

The total annual production of soap in the United Kingdom is estimated at 5,000,000 cwts. The exports in 1890 were 496,930 cwts., the declared value of which was £534,327.

LESSON 49.—BONES.

The objects required for this lesson are, the long bone of a leg of mutton or shank-bone of an ox, a burnt bone, and one which has been steeped in a solution of muriatic acid (spirits of salts) and water, and picture of the framework of an animal.

I. Qualities of Bone.—Tell subject of lesson, and let children examine the specimen, and thus discover that bone is hard, smooth, and rather heavy. If they try to bend it they cannot, and if they try to break it they cannot do so easily. It is too rigid to bend, and too tough to break.

Lead the children to see why bone has these two qualities by examining two specimens which have been prepared. Supposing, therefore, that you have three shank-bones, one just as it comes from the animal, another which has been carefully burnt in an open fire, and a third which has been steeped in acid, proceed thus:

Here is a bone the shape of the one which you could not break. It has been burnt. Bend it. It has broken easily, showing that it is very brittle. Here is another bone which has been soaked in acid and water. Break that. You cannot. It is soft and flexible; it will bend easily, but it is not strong enough to resist the pressure. Thus, then, you see that the bone as it comes from the animal is tough enough not to break when you press it, and strong enough not to bend when you press it. The burnt bone is hard but brittle, and so breaks easily when pressed, while the bone which has been steeped in acid is so soft and flexible that it can be bent in any direction. Both the latter have lost something which the former possesses. Explain what has been lost.

Bone is made up of two distinct kinds of substances, one an earthy compound, mostly *phosphate of lime*, and this has been taken out of the specimen which is soft and flexible. It was taken out by steeping the bone in a solution of muriatic acid and water, using 1 part of acid to 9 of water, and allowing the bone to remain in the liquor for some time. The other material is an animal substance called *gelatine*, and this has been taken out of the specimen which has been burnt.

In every 100 lbs. of bone there is about 30 to 40 per cent of earthy material, and from 60 to 70 of animal.

The bone which has been neither burnt nor steeped possesses both these substances, and so is strong, tough, and hard.

II. Use of Bones:—

A. TO THE ANIMALS WHICH POSSESS THEM :—

1. *Give Shape and Support.*—By reference to their own bodies and by examining pictures of animals children will see that the internal framework of bone which they possess gives to each that particular shape or form which characterizes them, whether fish, reptile, bird, or mammal. The bones also give support to each part of the body.

2. *Protect certain Organs.*—Again, by calling attention to the position of the brain, the heart, and the lungs, all inclosed by the bones, children will see that those delicate organs are thus shielded from injury, and so the life of the creature preserved.

3. *Give power of Movement.*—The bones also, by being in separate

pieces, and these pieces being united together in some cases by movable joints, enable the animal to move from place to place.

B. USES TO WHICH BONES ARE PUT WHEN THEY ARE SEPARATED FROM THE ANIMAL.—Let the children name any uses they know. Give other uses, and so work out the following:

1. *For the Handles of Knives, Forks, Tooth-brushes,* &c.—The following are the processes through which the bone passes in being prepared for this use. Kinds used: Shin and buttock bones of oxen and calves.

a. Extracting the Grease.—This done by boiling the bones in water for about twenty-four hours, in large open coppers, and skimming off the fat as it rises to the surface. The hollow bullocks' shank bones are boiled alone, as they yield the finest fat, which is sold to the makers of *butterine.* The value of this fat is from 35*s.* to 45*s.* per cwt., according to the quality. If the fat is not of the finest quality it is sold to the soap-maker. Any other kinds of bone which may be used are chopped in pieces and then boiled. The fat which is of inferior quality is sold to the soap-maker at 25*s.* to 35*s.* per cwt.

b. Bleaching.—This is done either by laying them in the sun or by means of a chemical process.

c. Sawn and turned into the shape required.

d. Soaked in turpentine for a whole day. Boiled in water for about one hour, and then polished, first with glass-paper, then with Flanders brick, and lastly with whiting on a damp woollen cloth.

e. Finished.—A small quantity of wax is now rubbed on quickly so as to fill up all the small pores.

The shavings, scrapings, and sawdust produced in these operations are used for making jellies.

2. *Distilled in large Retorts for the Manufacture of Sal-ammoniac.*—What is left in the retort after the ammonia is passed off is a black mass called *bone-black* or *animal charcoal.* This substance is used by sugar refiners to take the colour out of the syrup, and so produce white sugar.

3. *Burnt in Open Fires to produce Bone-ash,* which is used for manure and in the manufacture of porcelain. About 4500 tons is used annually for this latter purpose. Sometimes the bones are merely crushed and then spread upon the land, or they are dissolved in sulphuric acid, and thus made into what is called a *superphosphate of lime.*

4. *For the Manufacture of Gelatine.*—The principal operations in the production of gelatine from bones are the following:—

a. The earthy matter is extracted by steeping the bones in a solution of muriatic acid and water. Refer back to the specimen used in first part of lesson.

b. When the earthy matter is extracted the remaining portion is washed in clean water and placed in a solution of lime. It is then rewashed and dried. This is the raw gelatine.

c. The raw material is next purified. This is done by boiling it in a weak solution of acid and water, straining it through linen cloths. When quite pure it is poured while still warm on sheets of glass and then allowed to cool in a dry, airy place. In this state it is sold in the market, and used for various purposes, principally for alimentary substances.

III. Quantities used.—The demand for bones for manufacturing purposes is very great, and to supply that demand large quantities are imported into this country from all parts of the world. The total quantity imported in 1891 was 9678 tons, the value of which was £76,670.

The price of bones varies between £5 and £8 per ton, according to cleanness, size, and fatness. Bones taken from cooked meat yield far less fat than those taken out of the flesh before it is cooked, and the bones of horses contain so little fat that they are not worth boiling.

LESSON 50.—IVORY.

I. How known from Bone.—By a careful observation of a bone and ivory knife handle the children will discover that the latter substance is distinguished from the former by a number of lines of different colour proceeding in a somewhat circular direction, and forming minute, curved, lozenge-shaped spaces. Tell that no other animal substance is found in which these occur. Ivory, therefore, easily distinguished from bone by the presence of these marks.

II. Sources of Ivory.—Question the children so as to elicit what they may know, and tell what not known.

1. *Teeth and Tusks of Elephants, but especially the latter.*—Those of the Indian elephant weigh from 70 to 80 lbs. each; those of Ceylon are smaller, weighing from 25 lbs. to 35 lbs.—they are, however, of a fine quality, and of a bluish tint; those of Siam are very superior; those of Cochin-China are larger than those of India, often weighing 150 lbs. each; while those of Africa are larger than any of the others, some weighing as much as 175 lbs.

2. *Fossil Ivory.*—The tusks of the extinct mammoth, now found in great abundance in Siberia and Alaska, preserved in the frozen soil.

3. *Hippopotamus Ivory.*—This is supplied by the two projecting incisor teeth.

4. *Walrus Ivory.*—This is obtained from the two tusks of the upper jaw.

III. Uses of Ivory.—Let the children give any known, supply the rest.

Knife handles, brush backs, combs, piano keys.

Billiard balls and fancy articles.

The four former prepared by being cut out of the tusk by means of very fine circular saws. Then polished and bleached by exposure to the sunlight for two or three days. When bleached the ivory may be dyed.

Billiard balls are turned out of small tusks.

Fancy articles are turned and carved.

The dust produced in the manufacture of these articles is collected and used for making jellies.

The total amount of ivory imported into England during the year 1891 was 10,952 cwts., the value of the whole being £549,359.

The value of the tusks of elephants depends upon their size. Thus tusks weighing 70 lbs. each and upwards will fetch from £50 to £70 a cwt., while those which only weigh from 25 lbs. to 35 lbs. each are worth from £30 to £50 a cwt. The teeth of the walrus are worth from 6*d.* to 8*s.* a pound, according to the quality.

Lesson 51.—HORN.

The objects required for this lesson are, a horn comb, a horn or picture of one, and pictures of several horned ruminants.

I. Qualities of Horn.—Tell the children the subject of the lesson, and let them name the animals which have horns, as oxen, rams, and the goat. If stags are mentioned, show children how such horns differ from those of the bullock and the ram, and tell that the proper name for the former is *antlers*, and that they are composed of a substance resembling bone, and not horn proper. The present lesson will be on the horn of the ox.

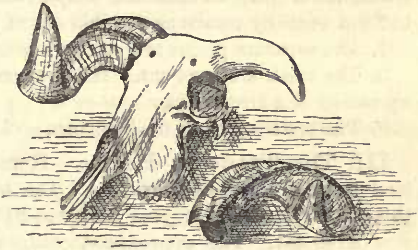
Let the children examine the horn, and describe it as a whole. It is conical, slightly curved, of a yellowish brown colour, hard, stiff, dull, and hollow.

Take a small piece of horn, say a part of a comb, and lead the children to discover its qualities: as fibrous, and the fibres are flexible, elastic, and translucent. Put a fibre in the flame of a candle; it frizzles and gives out an unpleasant odour.

Place a piece in hot water, leave it for some time, and then compare it with that which has not been soaked: the former is soft, the latter hard.

Show specimen or picture of the head of a ram, when children will see that though the horn you have is now hollow, it was not so when on the head of the animal; then it was the covering of a bony core which grew from the bone of the forehead, and the horn surrounded it like a sheath.

Refer to the fact that the ends of our finger-nails can be cut and yet no pain be felt. The same is the case with the outside covering of the core; the tip might be cut and the animal feel no inconvenience. If, however, our nails be cut to the quick, we immediately feel great pain. So if the core of the horn be injured it bleeds freely and the animal suffers pain. The children will thus see how cruel it is to strike the horn of a bullock with a stick, as is sometimes done by the drover when driving the animal to or from market.



A Sheep's Head, showing the Bony Core, and the way in which the Horn sheathes this.

II. The Uses made of Horn.—Let the children mention any use they may know. Supply what not known, and so work out that the solid tips are used for knife-handles and buttons, and the other portion for drinking-cups, shoe-lifts, &c. The principal use, however, is for combs of various kinds.

Processes of Comb-making.—The children to examine the horn and compare it with a comb, when they will see that it must have undergone some changes. Let them say generally what must have been done. Yes; it must have been cleaned, cut, flattened, smoothed, and formed in some way.

By the same method as that suggested in other lessons on manufactures work out the following processes:

1. Horn when taken from the head of the dead animal removed from the core.

2. Softened in warm ~~weather~~. water

3. Cleaned and split into two parts by circular saw while still warm. Split lengthways in the direction of the grain.

4. The slices thus cut are now placed between heated plates of metal and subjected to the pressure of several tons to the square inch. If needed of any particular colour it is now dyed.

5. The pieces are now softened again in warm water, then laid between cold iron plates and pressed level.

6. The form of the comb is now stamped out by means of cutters, which are of various sizes and shapes, and so placed on the slice as to form as many combs as possible out of the one piece of horn.

7. The separate pieces are now straightened and ground.

8. The teeth are next cut. If large combs, by stamping; if small, by means of a circular saw.

9. The teeth are next filed smooth, and the comb is then polished.

III. The Trade in Horns.—Horns are imported into England from all parts of the world. The total quantity brought into this country during the year 1891 was 6446 tons, the value of which was £189,451. The approximate values of horns at the present day are:—South American ox, 35*s.* to 80*s.* per ton; Cape, 35*s.* to 120*s.*; Australian, 6*s.* to 65*s.*; East Indian, 20*s.* to 60*s.*; according to the quality and the supply and demand.

LESSON 52.—GLUE.

I. Use.—As a cement to fasten pieces of wood together, leather on wood, &c. Why so used? Because fusible with heat of boiling water, hardening when cold, and adhesive. But soluble in cold water, so not adapted for cement when object exposed to the weather.

II. Of what made.—If not known, tell. From the refuse scraps called *fleshings* produced in trimming skins for tanning; from cuttings of tawed leather; from old leather which has been deprived of the tanning, and from the hoofs and waste of the horns of animals.

III. How made from Fleshings:

1. Soaked in weak lime-water, and then washed in baskets under a stream of clean water.

2. Drained, and then exposed to the air to cause any lime which may be left to lose its caustic properties.

3. Boiled and then clarified, being allowed to settle, when the impurities rise to the surface and are skimmed off.

4. Run into shallow coolers, consisting of wooden boxes 14 feet long, 12 inches wide, and 9 inches deep.

When cool it is an elastic cake, which is then taken out and divided into a series of blocks or *gobbets.*

5. The blocks are placed in wooden frames 12 inches by 7 inches by 6 inches, and provided with about a dozen slits, the whole much resembling a set of school-slate frames placed together. Each block is now cut horizontally into slices by means of brass wire stretched on a frame.

6. *Dried.*—The slices thus cut are laid out on a sheet of galvanized iron wire and exposed to the air for the purpose of drying and hardening. In the course of drying the slice of glue shrinks until its size is only one-half what it was in its moist state.

7. After the drying the glue is washed with warm water to remove the dirt; it is then dried again, and packed away ready for the market.

Ordinary glue may be rendered insoluble in water by mixing with it when prepared for use about $\frac{1}{50}$ of its bulk of bichromate of potash. When spread on the article to be cemented it must be exposed to the action of light.

A thin kind of glue called *size* is used for fixing the ochre and whiting brushed on walls; and one kind, now much used by papermakers, is prepared by dissolving soda in boiling water, and adding to it powdered rosin. When these are thoroughly united they are mixed with a glue solution and boiled together for ten minutes.

There are three qualities of glue made:—Common or town glue, worth 6*d.* a pound; strong Russian dark, 9*d.* a pound; finest kid, 1*s.* a pound.

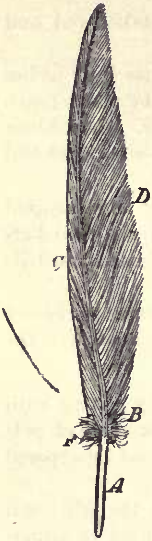
LESSON 53.—FEATHERS.

I. The Parts of a Feather.—Provide a perfect feather, say one of the quill feathers of a goose, or any other large bird. If no feather at hand make diagram. Children to point out the parts of the object and get the proper names, and so work out that a feather consists of:

1. The *main stem* or axis, composed of a hollow cylinder called the *barrel* or *quill* A, which is embedded in the skin of the animal.

2. The *shaft* B, which is a continuation of the quill, and consists of—

a. A four-sided *shaft* extending to the upper extremity of the feather, filled with a peculiar elastic substance termed *pith.* The shaft is of a horny texture like the quill, and is slightly curved.



Quill Feather.

b. A number of lateral expansions which spring from both sides of the shaft, consisting of plates arranged with their flat sides towards each other, tapering to a point at their outer ends, and called *barbs.* These are again provided with tapering processes termed *barbules.* The whole of this part is spoken of as the *web,* C D.

c. At the point where the shaft joins the quill the *accessory plume,* F.

II. The Kinds of Feathers on the Body of a Bird.—If possible get a bird and let the class observe the feathers as a whole, and give the position of each kind of feathers and their use to the bird.

1. Those which cover the body: these called *clothing feathers.*

2. The long feathers in the wings and tail, used in flight: these called the *quill feathers.*

3. The small soft feathers which grow on the skin beneath the covering feathers: these called *down.*

III. Classification of Feathers as used in Commerce.—Let the children mention the different kinds of feathers which they may have seen in use, and why so used. Systematize the answers, and so work out the following matter:

1. *Common Feathers.*—These are the plume feathers of water-fowl and poultry birds, and on account of their softness are used for stuffing beds, pillows, and cushions.

Question as to how these feathers are obtained. Plucked by hand off the birds, which are used as food. By reference to the vast number of geese, ducks, and other birds which are eaten in London and other places the children will at once see that an immense quantity of such feathers must be obtained every year. Tell that these feathers are prepared for use in the following way:

First, they are carefully dried; then beaten with a stick, and shaken through a sieve; and lastly they are baked so as to destroy all vermin.

Besides all those produced at home, we imported, in 1878–79, 20,602 cwts. of bed feathers, valued at £91,679.

2. *Down.*—This consists of the loose fluffy barbs which are attached to the lower part of almost all feathers, and the very small feathers which are found on some birds, called *accessory plumes.*

The growth of the down is developed principally in aquatic birds: the eider duck, the king duck, and the wild swan are remarkable for the softness of their down.

From the fact that the birds mentioned are not generally used for food children will see that the down cannot be obtained in the same way as common feathers.

Tell that the chief source of the best white down of commerce is the eider duck of Iceland and Norway, and it is obtained in the following manner:

In the month of May the female bird prepares her nest, lining it with down plucked from her own breast. In the nest the bird lays four or five eggs. The farmers then remove a portion of both eggs and down, whereupon further supplies are furnished by the duck. Again the farmers take away a portion of both eggs and down, and again the bird supplies more. And the third time the partial robbery is perpetrated. By these means about 3 oz. of rather brownish down is obtained from each nest. After the third abstraction the drake contributes about 1½ oz. of whiter material.

The gathered down is separated into different qualities, according to its weight, by stirring it up with a stick in a sieve: this at the same time gets rid of the dirt. The yield of cleansed down is about half the quantity originally taken out of the nests. When thus prepared the down is sewn up in little bags for export.

In 1878–79 about 8000 lbs. was imported into this country, and sold at 9*s.* a pound. The down afforded by swans, geese, and ducks is much heavier than that of the eider duck, 1½ lb. of the latter being sufficient to fill a bed coverlet.

3. *Ornamental Feathers.*—Question the children as to the sorts which they may have seen.

(1) Those of great beauty and brilliancy of colour, as of the *humming birds, birds of paradise,* &c. In these not only the feathers, but the skin also, are used as ornaments for bonnets.

In consequence of the present fashion of using these beautiful birds as trimmings for hats and bonnets, there is so great a slaughter of the birds that it is feared the beautiful creatures will be exterminated. Teachers of girls should speak against this fashion, and be careful not to follow it.

(2) Those in which the barbules are long and loose, giving beauty of form, as *ostrich feathers.*

a. Tell that the great demand for these feathers has led to the birds being reared artificially for the sake of the feathers, which are taken from the living bird. Hence in Africa, at the present day, there are many ostrich farms.

The bird yields its first plumes at the age of eight months, and continues to do so at intervals of eight months throughout its life, which is from twenty-five to thirty-five years. The first feathers are small, and of little value.

b. The gathering of the plumes is a delicate operation, and is performed either by plucking them out bodily or by severing them near the base by means of a sharp knife. It is said that neither method seems to cause the bird any appreciable pain. If that is the case well and good; but if pain is inflicted on the creature by the operation, then the wearing of ostrich feathers is to be deprecated.

c. The preparation of the feathers for market—

First, washed in soap lather, rubbed well with the hands, and passed through clean, hot water.

Second, if white, now bleached. First exposed to the action of the sun and dew for about a fortnight, next washed in water containing pure white chalk, and then passed through clean water. Next they are blued by passing them rapidly through cold water containing indigo. After this they are suspended in the fumes of sulphur, and lastly hung up on ends to dry, being occasionally shaken to open the barbs.

In 1891, 714,575 lbs. of ornamental feathers were imported into this country. The value was £983,983.

4. *Quills.*—Show a quill pen and a perfect quill. Tell that the goose is almost the only bird whose quill-feathers are utilized.

The quills for pens are obtained almost solely from the five outer wing-feathers, the second and third being the best, and those of the left wing having the preference.

It is said that those intended for pens are taken in the spring from the living bird, those which are taken from the dead bird being used for toothpicks, holders for the hair of artists' brushes, for anglers' floats, &c.

5. *The Preparation of Quills for Pens:*

a. Heated in sand at a temperature of 180° Fahr. This removes the grease, and causes the inner skin to shrivel up. The outer one is scraped off while warm. When the quill is cold it is hard and elastic.

b. Sorted and packed in bundles.
c. Nibs cut: best by hand, others by machine.

Lesson 54.—WHALEBONE.

The objects required for this lesson are, one or two pieces of whalebone, some illustration of its use, and a diagram of the Greenland whale showing structure of its mouth.

I. Introduction.—Show the substance. Get or give its name, and let the children say for what they have seen it used. Tell that though called *whalebone*, it is not obtained from the *bones* of the whale: it is not bone at all. Its proper name is *baleen,* and what it really is will be learnt presently.

II. Qualities of Whalebone.—If the specimen is large enough to be seen by all the children let them describe it, but if small call a child out of the class and let him do so, you calling the attention of the whole class to what he is doing and what he says. Thus work out that whalebone is hard to the touch, but yields to the knife; smooth, bright, and opaque.

Direct the child to take the strip and bring the ends together. He can do so easily: it is *flexible.* To let go one end, it returns to its former shape: it is *elastic.* To bend it backwards and forwards several times: it does not break: it is *tough.*

Next direct the child to take a penknife and press it on the upper end of the whalebone: a strip will split off, and another, and another. Let him try to make the strip shorter by splitting a piece off the end: he cannot. Children will thus see that whalebone can be split in its length only. Each strip can be pulled to pieces into little threads or fibres: so called *fibrous.* The baleen is made up of a number of hardened hairs cemented together.

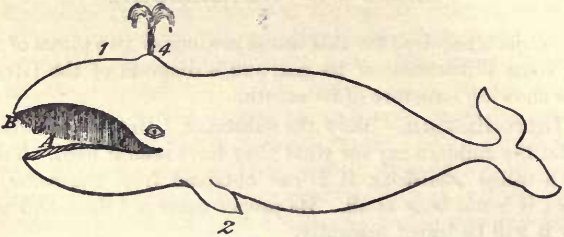
Put a piece in a glass of water: it floats: it is lighter than water.

Get an iron table-spoon. Fill it with sand, and in the middle place a small piece of whalebone. Make the sand hot. When heated take it out and compare with other specimen: it is soft, and can be bent into any shape.

In the evening previous to the lesson boil a piece of whalebone. Show specimen. Tell what you have done, and compare it with the unboiled, and also with a piece just heated, when children will see that though the heat has softened the substance, yet when it gets cold it is harder and darker.

III. Nature of Whalebone.—Tell that the baleen is found in the mouth of certain kinds of whales, of which the Greenland whale is the most important. Show picture of the whale, and draw attention to the whalebone in its mouth.

Tell that the whale is the largest of all animals in the world.

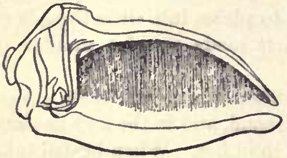


The Whale.—1, Upper part of head. 2, Flipper. 3, Baleen. 4, Blow hole. A, Lower jaw. B, Upper jaw.

Some have been caught which measured 80 feet in length, and even longer, and 40 feet round in their thickest part.

Now although the animal is so large, it feeds on small soft animals, some of which are not larger than shrimps, and even smaller.

The whale needs a great number of these tiny creatures for one meal, and it can get as many as it wants, because there are millions swimming about in the sea where it lives, and then the animal has a very large mouth, and so can catch a great number at one time. When the whale is hungry it swims with its mouth open under water, and when it shuts its mouth the little animals are of course all kept prisoners. A class of forty children could all stand at one time inside the whale's mouth, and if they stood on the creature's tongue and stretched their arms up they would not be able to reach the roof of the mouth.



Skull of Whale with Baleen.

Single Plate showing fringe on inner edge.

The whale does not want all the water which he has taken into his mouth, he only wants the food, so he has the power of sending out the water and keeping the food. This is how he manages it. He has no teeth, but hanging down from the gum of the upper jaw are a number of plates or *blades* of whalebone, just as shown in the picture. All these plates are fringed on the inner side. The blades near the front of the mouth are only a few inches long, but those in the middle are from 12 to 15 feet in length. Their breadth at the root is 10 to 12 inches, and about ½ inch thick. The number of blades on each side is commonly about 300. There are no plates in the lower jaw. When the animal shuts its mouth, and strains the water through the fringes of the plates the food is of course retained in the mouth. A full-grown whale will yield about one ton of whalebone.

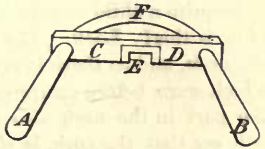
Arouse the curiosity of the children by telling them that there are many more wonderful things to be learnt about whales, but that the lesson on whales as such must be given at another time.

IV. Uses of Whalebone.—Let children mention any known; tell the other uses; and so work out that some umbrellas—for instance, the very best carriage umbrellas—have the frames or *stretchers* made of it instead of steel. Thin strips are also used to stiffen the stays worn by women. It is split into fibres, which are used instead of bristles for making coarse brooms and brushes. Again, it is cut into strips and plaited into bonnets. Sometimes artificial flowers are made of thin strips which have been dyed.

From the thick part of the blades are made knobs for walking-sticks, and sometimes the whole stick itself. The thin shavings made in preparing the substance for the different uses named are sold to stuff cushions and other such things.

V. Preparation of the Whalebone for Use.—Before cutting up the blades for use they are cleansed and softened by boiling for about two hours in long coppers.

While still hot the blades are fixed in the wooden vice of a carpenter's bench in a convenient position for being planed or shaved into the required shape by means of a tool like the picture. The notch of the tool is applied to the end of the blade farthest from the operator, and is then drawn towards the person so as to cut always in the direction of the fibres and never against them. These slices are then dried and planed smooth on all their surfaces.



A B, Handles. C D, An iron plate. E, Guide Notch. F, Knife.

Polishing.—Two methods used: In one it is scraped with pieces of glass, then rubbed with emery-paper, and then with rotten-stone or woollen cloth. A second way is to rub the substance with ground pumice-stone and finish with dry quick-lime.

The present price (June, 1892) of Greenland whalebone is from £2700 to £3000 per ton, according to quality. The total quantity of all kinds imported into this country in 1891 was 4772 cwts., the declared value of which was £209,395.

LESSON 55.—CORK AND THE CORK-TREE.

The objects required for this lesson are, several cut corks of various sizes, a piece of cork such as is used for corks, a glass of water, a wine bottle, and a picture of the cork-tree.

I. Qualities and Uses of Cork.—Commence the lesson by letting the children examine and describe a large new cork, such as is used for a wine-bottle, and so work out that it is cylindrical in shape, of a light brown or tan colour, soft, porous, tough, and light. Tell from what obtained, so a vegetable substance.

Call attention to the nature of the pores; they do not communicate with each other, so that water cannot pass from one to another, on account of this the substance is *waterproof*. Let the children give the uses to which it is put on account of this quality, namely, for inner soles of shoes and for stoppers to bottles, casks, &c.

Take the wine-bottle and the new cork. Children notice that the cork is thicker than the neck of the bottle. But you wish to use it as a stopper for that particular bottle. What must be done? It must be forced in. How? By pressure. Do this, driving the cork in so that the end may go beyond the neck. What has the pressure done? Caused the particles of which the cork is composed to occupy less space than they did before the pressure was exerted. So cork is *compressible*.

Require a child to take the cork out with his hands. He cannot. How is this? Look. The lower end of the cork is below the end of the neck, and as there is no pressure there, the particles of the cork which were before compressed have resumed their former size, and the part in the neck also presses against the sides. By this they will see that the cork is *elastic*. It is the compressibility and elasticity of cork which render it useful for stoppers to bottles.

Compare a bottle cork with a bung, and both with a piece of cork as sold. Children will see that not only are bungs larger than bottle corks, but are more porous in their length, and are less elastic, and so afford a less secure fastening. This difference is the result of the way in which they are cut. Bungs for casks are so cut that their upper and under sides correspond to the two sides of the sheet out of which they are cut, whilst bottle corks are cut in the opposite direction.

Place a piece of cork in a basin of water, and let a child endeavour with a stick to keep it under the water. He cannot. It will come to the surface. It is very *buoyant*. It is much lighter than water, and the lightest of all vegetable substances except elder-pith.

On account of its lightness it is made into floats to fishing-nets, life-buoys, or *life-jackets* as they are called, and used for lining some parts of life-boats, also for hat-linings, and even the bodies of hats. The early shed bark, which is rough and very porous, is used for ornamental rustic work. Hold a piece of cork in the flame of a candle. Call attention to what takes place. The cork burns with a bright white flame, leaving a black bulky mass behind. Tell children that the black mass is really charcoal, and that it and the smoke emitted while burning is collected, and forms the substance called *Spanish black*.

The waste from cork cutting, which generally amounts to a third, is applied to filling cushions and horse-collars. It forms a very valuable material with which to stuff mattresses, especially for use at sea, as it is damp-proof and light, and can be used as rafts in the case of shipwrecks. It is also used in the manufacture of cork carpets, kamptulicon, and linoleum. In France it is used in the manufacture of pasteboard.

II. What Cork is, and how obtained.—Procure several pieces of cork as imported. Children to say what it appears to be. The bark of a tree. This is what it really is, and now they must learn something about its nature.

1. *The Tree.*—Let children observe a picture, describe it as far as they can. Give what cannot be found out, and so work out the following matter:

The cork-tree is an oak found in Spain, Portugal, the southern parts of France, and in Italy. When full grown it is about forty feet in height (compare with height of house), and from two to three feet in diameter.

The leaves are entire, oblong, oval, about two inches long and one and a quarter broad, with serrated edges, and slightly downy on the under sides. The foot-stalks are very short. Compare with leaves of English oak. The leaves remain green all through the winter. The acorns are oval, rather large, and of a sweet taste.

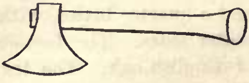
The Outer Bark.—If possible obtain several kinds. Children compare these. Some thicker, rougher, and more porous than others. Tell how this is brought about. The outer bark of this tree grows unusually large, and when removed is speedily again renewed. This second growth is of a finer quality than the first. If the second is removed a third grows in its place, and this again is of a finer texture than the second, and so on. Thus it is that the very finest cork is the produce of the oldest trees. It is found that the removal of the bark artificially improves the condition of the tree and prolongs its life.

Cork Oak.

The first barking takes place when the tree is about twenty-five years old. This bark is of a very inferior quality, and forms the virgin cork of commerce, now used for ornament in greenhouses, gardens, &c. Ten years after the trees are barked again; the second bark, though of better quality than the first, is not thick enough to make good corks for bottles, and is used principally for floats of fishermen's nets. After the tree has attained the age of forty-five or fifty years the cork is found to possess the qualities necessary for making good bottle corks, and from this period the trees are regularly barked every eight or ten years until they are about one hundred and fifty years old.

2. *How the Cork is removed from the Tree.*—By the help of a diagram lead the children to realize how the outer bark is taken off.

The months of July and August are those in which the operation is performed. In order to remove the bark two incisions are made opposite each other the whole length of the body of the tree. Next incisions are made one immediately below the branches, and another at the surface of the ground. Now other cuts are made round the trunk at different heights, thus dividing the bark into broad planks, and the cork is removed by inserting a blunt



Hatchet used.

instrument or the handle of a hatchet between the outer and inner bark, having been previously loosened by smartly tapping them with a hammer. Great care is required to be taken in this operation not to injure the inner bark, for if this were destroyed there would be no further formation of cork-bark and the tree would perish.

Stripping the Cork off the Trees.

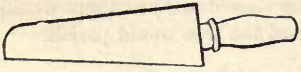
3. *How the Cork is prepared for the Market.*—By comparing a piece of cork as sold with a piece as first taken off the tree the children will see that it must have passed through some processes. Tell these.

After having been scraped the planks, or *tables* as they are called, are cut into pieces, slightly charred to contract the pores and destroy insects, and then pressed flat with stones.

In Catalonia it is divided into pieces about 3½ feet long and 1½ feet wide, and boiled in water, which adds, it is said, to the quality of the cork. When the tables are taken out of the water their surfaces are scraped, and then they are dried in the sun. By these means the pores are more effectually closed and the colour improved, the sun-dried variety having none of the blackness of that dried by artificial heat. The prepared tables are tied in bundles for transport to market, a large quantity being sent to this country. In 1891 the importation of raw cork was 13,258 tons, 6672 of which came from Portugal. In the same year 442,620 tons of manufactured cork were imported, of the declared value of £632,481.

III. The Manufacture of Corks.—In England the chief use of cork is for making stoppers for bottles and other vessels, which are always known as *corks*. Until recently these were all cut from the tables by hand.

The cork-cutter sits at a bench, which has a ledge round it, to prevent the corks falling off. The knife, which has a sharp blade about 6 inches long, tapering, and with a rounded end, is placed edge uppermost in a notch on the bench, or held in the hand. By a dexterous circular cut the cork is turned out of the table, the size corresponding to the thickness of the table. The cork is then cut into the particular size required.



Cork-cutter's Knife.

IV. The various uses to which Cork is put in the Countries where the Tree grows naturally:

Spain: Bee-hives, kitchen-pails, sash frames for garden lights, and the cuttings for pillows.

Portugal: Roofing of houses, lining for garden-walls, and fencing for poultry-yards.

Italy: Images, crosses carved out of it, footpaths paved with it, and buttresses of houses made of it.

Turkey: Cabins for cork-cutters and coffins.

Morocco: Drinking vessels, plates, tubs, and house conduits.

Algeria: Shoes and wearing apparel, saddles, horse-shoes, armour and boats; landmarks, furniture, stable-racks, and door-steps.

LESSON 56.—INDIA-RUBBER.

The objects required for this lesson are, a thin and a thick piece of india-rubber—not ink-eraser—a glass of water, five small phials, some methylated spirits, turpentine, naphtha, and pictures of india-rubber plants.

I. Qualities of India-rubber.—Tell the subject of the lesson, and the fact that it is a vegetable substance. Show specimen, and let the children give its qualities, those not known to be developed by the methods indicated in the lessons on qualities in Part III. of this Manual.

Thus work out that india-rubber is soft to the touch, flexible, tough, elastic, waterproof, inflammable, burning with a white flame, and giving off much smoke and a strong odour.

Respecting its elasticity tell the fact that it is increased by moderate warmth and lessened by cold. If it is stretched out while warm and in the extended state is cooled it loses its elasticity and remains extended. When it is again warmed it regains its elasticity. It is this quality which enables it to be made into what are called *elastic webbings,* and which are used for glove-bands, braces, and bandages used by the surgeons.

When plunged into hot water or heated before the fire it becomes soft, and melts at a temperature of 250° Fahr. The freshly-cut edges are easily joined by pressure and a little heat.

As to the nature of the solubility of india-rubber proceed thus: Take the five phials, mark them Nos. 1 to 5, No. 1 to be partly filled with cold water, No. 2 with warm water, No. 3 with spirits of wine, No. 4 with turpentine, and No. 5 with naphtha. Into each of these put a small piece of india-rubber, and then shake the bottles well for some time. Children say what has taken place. The pieces of india-rubber in the cold and warm water and in the spirits of wine have not altered their size or appearance, while those in the turpentine and naphtha have begun to *dissolve.* So we can say that india-rubber is *insoluble* in water and spirits of wine, but *soluble* in turpentine and naphtha. Show some india-rubber which was dissolved in turpentine some time before. It is still a fluid. If teaching elder children lead them to see that it is a non-conductor of electricity—one of the best.

II. Uses of India-rubber.—Let the children give all the uses they know to which india-rubber is put. Supply the rest. To remove black-lead pencil marks from paper. Its name was given to it because of its being so used. It is cut into thin strips, and these are put into the bands of cotton, woollen, and silk gloves, also into braces. India-rubber is mixed with sulphur and other substances and then called *vulcanized rubber*, which is used for many purposes, as ink-erasers, elastic bands, door-springs, gas-tubes, balls, &c. It is also mixed with pitch, and then made into combs, watch-chains, pen-holders, and many other things. Such articles are said to be made of *vulcanite.*

When dissolved, and a substance called *shellac* mixed with it, it is used as a cement by the ship-builder. When dissolved in naphtha it is spread on woollen cloth to render it impervious to water. Such materials are sold under the name of *waterproofs,* and a coat or cloak made of such stuff is often spoken of as a *Mackintosh*. When rolled into sheets it is used to cover (insulate) telegraph wires.

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III. Sources of the Raw Material, and how obtained:

1. *Sources.*—Tell the following, illustrating by means of pictures:—India-rubber is obtained from a variety of plants yielding a milky juice, which will coagulate on exposure to the air into an elastic fibre, and which grow in many parts of India, Africa, and South America. Some of these plants are large trees—30 to 50 feet high—others, as

those of some parts of Africa, are climbers. The Assam, Java, Penang, and Rangoon rubber is the produce of the india-rubber tree proper (*Ficus elasticus*); the rubber of Para, South America, is from one of the same family of plants as the castor-oil.

2. *How obtained.*—Tell the fact that the rubber is obtained from the elaborated or descending sap. If the children have had the lessons on PLANTS, they will be able to say in what part of the tree that sap is found, and to suggest how it might be obtained.

India-rubber Plant.

Give the exact mode as adopted in South America, illustrating on slate, and leading the children to see why each thing is done.

At the beginning of the dry season the collector goes through the woods in which the trees are growing, and lays at the base of each tree that is ready for tapping a number of small cups of burnt clay, with one side rather flattened. See picture on next page. Fifteen of such cups hold a pint.

The collector carries with him a small axe, and, arriving at the tree, he takes the instrument in his right hand, and, striking in an upward direction as high as he can reach, makes a deep, upward-sloping cut across the trunk, which always goes through the bark, and penetrates one inch or more into the wood. The cut is one inch in breadth.

Quickly stooping down, he takes a cup, and pasting a small quantity of clay on the flat side, presses it to the trunk beneath the cut, and the juice, which is of a perfect white colour, commences to exude.

At a distance of four to five inches, but at the same height, another cut is made, and another cup is fastened on; and so the process is continued until a row of cups encircles the tree at a height of about six feet from the ground. Tree after tree is treated in like manner, until the tapping required for the day is finished.

The juice exudes from the cuts for about three hours or longer. The quantity of milk that flows out from each cut varies, but if the tree is large, and has not been much tapped, the majority of the cups will be more than half full—some full to the brim.

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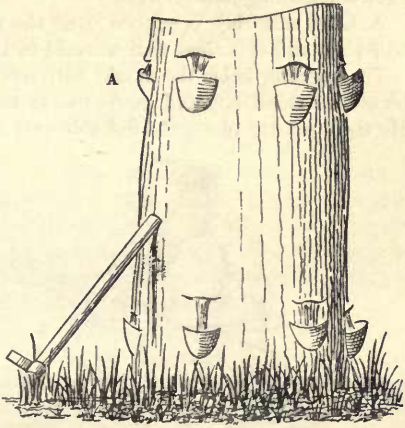
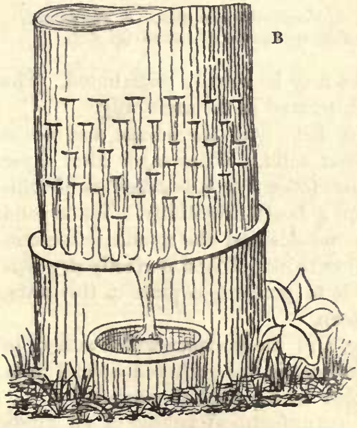
On the following morning the operation is performed in the same way, only that the cuts beneath which the cups are placed are made six to eight inches lower down the trunk than those of the previous days. Thus each day brings the cups gradually lower until the ground is reached. See picture A.

Going from tree to tree the collector empties the contents of the cups into a large vessel called a *calabash*, which he carries in his hand.



Method of Collecting the Sap. Copied by permission from Spons' Encyclopedia of Industrial Arts.

In some parts of South America another mode of collecting is pursued. The loose outside bark is cleared off to the height of three feet. Beneath this a gutter or raised border of clay is pasted to the trunk, enclosing one half of the circumference of the tree. Cuts are thickly made in the bark above this, from which the milk flows down to the gutter, when it is conveyed to a vessel placed to receive it. See picture B.



Another way of collecting the Sap. Copied from Spons' Encyclopedia.

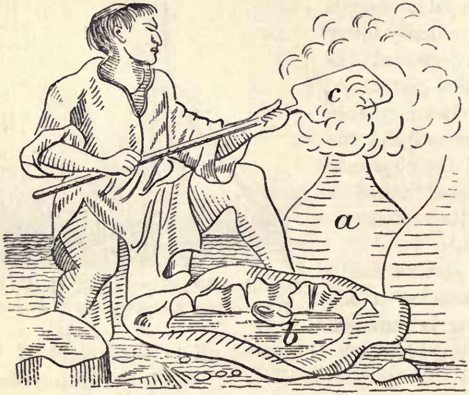
IV. The Preparation of the Milk for the Market.—As the children could not possibly know anything about this it must be told, attention being drawn to the diagram.

The milk thus collected is next moulded. The mould is a wooden instrument, somewhat resembling the paddle of a canoe.

A fire is made in a jar open both at top and bottom, wood and palm-nuts being used for fuel.

A little soft clay is rubbed over the mould to prevent the milk adhering, and it is then well warmed in the smoke of the fire.

The operator holds the mould with one hand, while with the other he takes a small cup and pours two or three cupfuls of milk over it. He then quickly places the flat side over the mouth of the jar, moves it swiftly round so that the smoke may be equally distributed. The opposite side of the mould is then treated in the same way.



a, The jar in which the fire is made. b, Vessel with raw juice. c, The mould.
Copied by permission from Spons' Encyclopedia of Industrial Arts.

The coating of milk on being held over the smoke assumes a yellowish tinge and gets somewhat solid. When layer after layer has been thus treated, and the mass (*biscuit* as it is called) is of sufficient thickness, it is laid down on a board to solidify. When solid it is cut open along the edges on one side and the mould taken out. Biscuit-rubber is from 4 to 5 inches thick. When perfectly dry it is sent to the market. It is possible to purchase a piece in this state, and the layers can be distinctly seen.

The waste droppings of rubber, and the portions which adhere to the bottom of the cups and other vessels, are gathered up and form what are called the *negrohead rubber* of the English market.

The total amount of raw and manufactured rubber of all kinds imported into this country in 1891 was 307,303 cwts., the declared value of which was £3,714,322. The value of the manufactured articles exported from this country in the same year was £1,242,794.

V. The Processes of Manufacture.—The necessity for some operation to fit the raw material for the different uses to which it is put will be obvious, and the nature of those operations in a great measure determined by the children from a consideration of some of the qualities of the substance. Thus if the children observe a piece of the raw material they will see that it is in layers, and that there are pieces of dirt mixed up with it. How can it be cleansed? Not by fire, because it is inflammable. But if by water, how can the water reach all parts, because it is waterproof? Hence it must be softened and pulled to pieces in some way. If, however, it is pulled to pieces it could not be used in that state, so it must be made into a solid mass again. Having thus worked out the necessity for each step in the preparation, give the exact mode. Thus:

1. *Washing and Drying.*—It is boiled in water for some hours; this softens the rubber. All pieces which sink are put by themselves, as these contain impurities, as sand, clay, &c., and those which float are yet mixed with leaves, wood, &c. The rubber is then washed in a machine somewhat resembling the wringing-machine of domestic use. The rollers are set at different distances in the various washings, and at last the rubber leaves the machine in long sheets with rough surfaces.

2. *Drying.*—This is effected in drying-rooms heated to 90° Fahr. by steam-pipes. The direct rays of the sun are kept away by painting the windows white or yellow. When dry it is stacked for future use.

3. *Masticating.*—The washed rubber is next put into a machine called the *masticator.* In this the rubber is made to pass between fluted rollers which are kept revolving.

4. *Blocking.*—The masticated rubber is then taken to the blocking-machine, in which it is pressed into a mould so as to form a compact block. When sufficiently pressed the moulds are placed in cool cellars or ice-houses until perfectly set and hard, when the moulds are emptied. The block remains in ice until required for use. Some blocks are square, others cylindrical.

Sheet Rubber.—When sheets of rubber are required the blocks are cut into different thicknesses. The square blocks are fastened on to a plate which can be raised to the thickness of the sheet required. This passes forward to a knife which is worked by machinery, and a current of cold water is kept constantly falling on the knife. When cut the sheets are hung to dry and season.

Tape Rubber.—Fillets or tapes are cut from the sheets. These are kept stretched for some time, being kept cold during the process.

When put into warm water the strips regain their original dimensions, but are very much strengthened. By repeating the operation the strength of the thread may be increased five or six fold.

If the strips are very fine they are called *thread rubber,* and are used for elastic webbing.

LESSON 57.—GUTTA-PERCHA.

The objects required for this lesson are, a piece of sheet gutta-percha, such as is used for the outer sole of a shoe, a piece of raw percha, some hot water and naphtha, also a picture of the gutta-percha tree.

I. Introduction.—Show a specimen; give its name, and notice the pronunciation (per'tsha). Tell the fact that it is a vegetable substance, obtained from the sap of a tree.

II. Distinguishing Qualities.—Children to examine the specimen, and so discover that gutta-percha, when prepared for use in sheets, is a brown leathery-looking substance, hard to the touch, but readily yielding to the knife; tough, flexible, and smooth, and waterproof. Is very inflammable, burning with a white flame, sending off much black smoke and a peculiar odour.

Place a piece in hot water; it softens, and when soft is plastic. It hardens again when cool. It is non-elastic. Is soluble in naphtha.

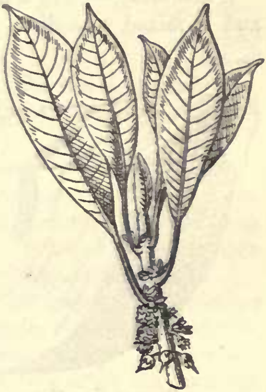
At some time previous to the lesson put a small piece in a damp place, and another piece into some acid. Do the same with two small pieces of iron. Now compare the substances. The iron is rusted and corroded; the gutta-percha is unchanged. Tell that if exposed to the air for any length of time it gets very brown and brittle.

If teaching elder children show that it is a non-conductor of electricity.

III. Uses of Gutta-percha.—Let children give those they know, and supply others. For soles of boots and shoes, because flexible and waterproof. Used in thin sheets for other purposes where it is necessary to keep out water. For cups, and for articles used for medical and surgical purposes, because easily moulded into required shape. Do not break, and are unaffected by acids.

For picture-frames, whistles, toy whips, and other useful and fancy articles, because easily moulded. For covering (insulating) telegraph-wires, because a non-conductor of electricity, and because it can be easily worked. It is also used for pipes for water, speaking-tubes, &c., and by surgeons for splints, and covering moist applications to retard evaporation.

IV. How Gutta-percha is obtained.—The produce of the Taban-tree (*Isonandra gutta*), a tall tree, and a native of Singapore, Borneo, and other Malayan islands, to which districts it is confined. The leaves are oval, leathery in texture, green above, but having a shining orange colour beneath, and attached to the stem by long stalks (petioles). The wood is spongy and of no economic importance. The milky sap is the gutta-percha of commerce.


Gutta-percha Plant.

Very little if anything was known of the substance in Europe until the year 1845, when it was introduced by Dr. Montgomerie. "I may not," says the Dr., "claim the actual discovery of gutta-percha, for though quite unknown to Europeans, a few inhabitants of certain parts of the Malay forests were acquainted with it. It was occasionally employed to make handles instead of wood or buffalo-horn. So long ago as 1822, when assistant-surgeon at Singapore, I was told of gutta-percha in connection with caoutchouc."

The manner of procuring the gutta-percha in the neighbourhood of Perak, says Mr. Murton, is as follows:

Immediately after the rainy season the collectors go to the forests, mark the mature trees, and then fell them to the ground at a distance of from 6 to 14 feet above the earth, the men standing on wooden stages while doing so.

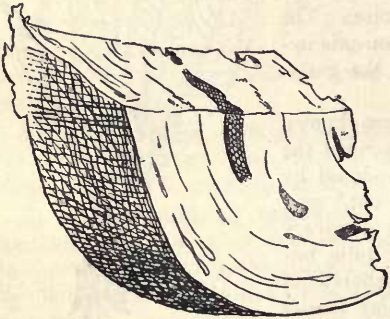
As soon as the tree is felled the branches are lopped off. Incisions are then made in the bark at different places accessible, the outside bark being also removed in various parts. In some districts the bark is beaten with mallets to accelerate the flow of sap, which continues to exude for about an hour from each incision, and is caught in palm-leaves, cocoa-nut shells, and other receptacles, much, however, escaping to the ground and being lost. One tree yields about 1½ lbs. of material. The sap thus obtained is boiled in iron pans to get rid of the watery particles. While boiling various substances are added;

in some cases cocoa-nut oil, in others lime-juice, and generally in Borneo about 20 per cent of scraped bark, which is considered to improve the colour of the percha.

When cold it is sent to the merchants, who prepare it for exportation by making it up into balls weighing about 1¾ lbs. each, or into large blocks. It is imported into this country in both these forms.

V. The Processes of Manufacture:

1. *Cleansing.*—Show a piece of raw material. It is not very dense and is mixed with dirt. This must be got rid of. How can the inside be reached? Cut in slices. Tell how done. But still the dirt is in the material. How can it be taken out? Cannot be purified in the fire, because inflammable. Cannot be washed out, because impervious to water. But it can be softened by hot water, and when soft it could be pulled to pieces and the dirt could be reached.



Piece of Raw Gutta-percha.

Describe how this is done. The material is now taken to the ticking-machine, where it is passed through a pair of fluted rollers towards a rapidly revolving wheel furnished with a number of cutters attached to its circumference; these chop off the gutta in flakes.

2. *Kneading.*—Compare the shreds thus obtained with the sheet for shoe-sole. Thus lead children to see the necessity for a further operation. Tell how it is kneaded into a compact mass by being again placed in hot water and *masticated* as it is termed, then strained through wire-gauze, and then made into blocks ready for future use. If for thin sheets it is rolled between heated steel-rollers, and if for such objects as cups, picture-frames, &c., it is moulded while in a soft state.

The imports of gutta-percha from all countries in 1891 were 60,911 cwts.; value, £734,879. The re-exports were 6408 cwts.; value, £57,106. The approximate London market value of gutta-percha is from 6*d.* to 3*s.* 6*d.* per lb., according to quality.

Lesson 58.—CAMPHOR.

I. Qualities of Camphor:

1. *By Observation.*—A solid substance, white, hard to the touch but yielding to the knife, tough, translucent, crystalline, aromatic odour, bitter pungent taste.

2. *By Experiment.*—Inflammable, burning with a white flame, and giving off much black smoke; fusible at a low temperature; melts at 347° Fahr., and boils at 399° Fahr. Very volatile; sparingly soluble in water, but entirely so in spirits of wine. 100 parts of spirit will dissolve 120 parts of camphor, the solution called *camphorated spirits.* If this is poured into water the camphor reappears in the form of white flakes.

Toughness overcome by addition of a few drops of oil.

For Elder Children.—If a few fragments of camphor be scraped off from a lump and allowed to fall upon the surface of clean water they move rapidly on the surface. Some of the pieces spin round in different directions, some move rapidly, others slowly.

If a drop of oil be placed on the water the fragments of camphor are brought to a dead stop. If the camphor be placed on a very thin plate of talc, and this deposited carefully on the water, the raft will immediately commence to move about. A drop of oil will cause the motion to stop.

If a piece of camphor with square base is lowered so as to touch the bottom of a shallow glass of water, the whole surface of the water becomes agitated with rapid pulsations at about 250 per minute. When the water has dissolved all the camphor the pulsations gradually decrease.

II. Uses of Camphor.—The strong pungent odour of camphor is very much disliked by moths and other insects. On account of this it is put into cabinets of preserved specimens, &c., and in drawers and boxes which contain woollen garments or fur, to prevent the clothes-moth from laying its eggs in them. The little grubs which come out of these eggs feed upon animal substances, and so destroy the articles by gnawing holes in them. When so destroyed they are said to be *moth-eaten.*

Camphorated spirits is a good remedy for unbroken chilblains, and also for scalds and bruises when the skin is not injured. It is also used as a medicine, two or three drops taken on a lump of sugar will often ward off a cold. It is also a valuable remedy for diarrhœa, six drops poured on a lump of loaf-sugar is the proper dose.

III. Means by which Camphor is obtained:

1. *The Source.*—The tree from which camphor is obtained is found in Japan, Java, Sumatra, and Borneo. It belongs to the family of the laurels, but it is a much larger tree than any of the laurels which grow in this country, attaining the height of 50 feet and more. The bark is smooth and greenish, the wood white and fragrant. The leaves are simple, lance-shaped, without any notches, and joined to the tree by very long stalks. The flowers are small, white, formed of six petals, and destitute of a calyx.

Camphor Tree.

2. *How obtained from the Tree.*—The camphor is found lodging everywhere in the fibres of the wood; also in the pith, but most abundantly in the crevices and knots. The mode of obtaining it differs in the several countries.

In *Sumatra* and *Borneo* the wood is split with a wedge and the camphor taken out in the form of crystals. In this way as much as 20 lbs. is obtained from one tree.

In *Formosa* the following method is adopted. When a tree is cut down the best parts are reserved for timber, the branches are chopped into pieces and subjected to distillation in jars.

The stills consist of a wooden trough coated with clay and half filled with water. Boards pierced with holes are fitted on the trough, and above these are placed the jars containing the chips. The jars are covered by earthenware pots, and the joints made air-tight by means of hempen packing.

When the fires are kindled the generated steam passes through the holes in the boards, and saturating the chips causes the camphor to pass off in vapour, which, rising to the cooler parts of the pots, settles in the form of crystals. These are afterwards scraped off and form the crude camphor, which is afterwards purified. The purification is effected by a second distillation. The crude camphor, as it is still called, is now packed in large vats provided with small holes in the bottom through which an oily liquid escapes. This is called *camphor-oil.*

In *China* the mode of obtaining the camphor is as follows. The chips are first cut up, steeped for two or three days in water and then boiled, being continually stirred with a stick until the grains of camphor begin to adhere to it in the form of a white jelly. The fluid is then poured into glazed vessels, and is left at rest for some hours, when the camphor is found in a mass.

The crude camphor is purified in the following way:—

At the bottom of a copper still is placed a layer of dry powdered earth from an old wall.

On this a layer of crude camphor is laid. This is again covered with earth, and this with camphor, and so on until the still is full. The top layer of earth is covered with green mint.

A second vessel, made of straw, and covered with clay on the outside, is placed over the still, and well secured. The whole is now placed over a fire, and the heat causes the camphor to pass off as vapour, which is caught in the upper vessel, where it crystallizes, and is afterwards taken out and exported.

The camphor, as brought to this country, is not pure enough to be used for medicinal purposes, and so is again purified.

The impure camphor is mixed with from three to five per cent of slaked lime and one to two per cent of iron filings. These are well sifted, and then placed in thin flasks of flint-glass with flat bottoms. These flasks are called *bomboloes.* They weigh about 1 lb. each, and are 12 inches across. The flasks are then placed in sand and heated on metal plates, the heat being supplied by a furnace in the outside of the room. The temperature is gradually raised until sufficient to melt the camphor.

When the mass has become fluid the sand is removed from the upper part of the flask, and a paper stopper put into the neck to partially close it, and covered with a glass shade. The heat is then carefully preserved at a point sufficient to cause the camphor to pass off in vapour—sublime it—but not to remelt it. As the vapour rises to the cooler part of the flask it solidifies on the interior as a semi-transparent cake, leaving all impurities behind.

When the sublimation is complete—after about forty-eight hours—the flasks are taken out, and cold water is sprinkled on them. This causes them to break, and the pure camphor is removed from them in the form of large bowls or concave cakes about 10 to 12 inches in diameter, 3 inches thick, and weighing 9 to 12 lbs.

There is no official account of the quantity of camphor imported into this country in 1891; in 1870 it was: unrefined, 12,368 cwts.; refined, 2361 cwts.; total, 14,729 cwts.

LESSON 59.—PAPER.

Matter for a Lesson on Paper to Elder Children.

I. Qualities—supposed to be known.

II. Different Kinds of Paper.—All paper may be classed under one or other of the following kinds:

1. *Writing Papers.*—White or coloured, plain or fancy, and used either for letters, envelopes, copy-books, account-books. Cut into sheets of various sizes, as note, letter, foolscap. Sold by the *sheet*, *quire* of 24 sheets, or *ream* of 20 quires.

2. *Printing Papers.*—White, or slightly coloured (toned), and used for newspapers, magazines, books, plates, maps, music, cheques, bank-notes, &c.

3. *Wrapping Papers*, as brown paper, thin, glazed, and thick grocery papers, sugar blues; tissue paper, white and coloured.

4. *Drawing Papers*, as cartridge paper, fine drawing paper, and millboards.

5. *Blotting Papers*, white and coloured.

III. The Materials of which Paper is made:

1. Rags of all sorts.
2. Refuse of flax from the linen manufacture.
3. Hemp, in the form of old ropes.
4. Fibres of jute.
5. Esparto grass, chiefly from Spain.
6. Straw. Rye straw considered the best.
7. Wood of the fir-tree.
8. Waste paper of all kinds.

IV. The Processes of Manufacture:

First—REDUCING THE RAW MATERIAL TO PULP:

1. *When made of Rags.*—The rags sent to the paper-maker packed in bales, and undergo a certain amount of sorting.

a. Dusting, to get rid of dry dirt.—This preliminary purification is generally done in a machine called a *thrasher*, and which consists of a wooden box divided into two portions by a wire gauze. In the upper portion a shaft revolves, bearing a number of teeth similar to and alternating in position with other stationary teeth at the top of the box. The rags are supplied at one end of the box and discharged at the other, the dust having escaped through the wire gauze into the bottom division.

b. *Cutting and Sorting.*—These operations are performed by women, who stand at tables, each table has a broad knife firmly fixed in it. Before the women are placed wooden boxes, the bottoms of which are covered with wire gauze. The women cut the rags into pieces about two to five inches square, and put them into the boxes, according to the colour and quality of the material of which they are composed. The cut rags are again passed through a dusting machine.

c. *Boiling.*—The cut rags are next placed in a large vessel and boiled with water and lime, caustic soda, or some other alkaline substance. By this process all grease and colouring matter are removed.

d. *Breaking*—that is, being reduced to a partial pulp.—This is done in a machine so constructed that the rags are made to pass between revolving knives, which can be brought closer together, as the material is cut up into very fine shreds. When it leaves this machine it is called *half stuff.*

e. *Bleaching.*—The half stuff is now put into a machine called a *poacher*, where it is mixed with a bleaching powder dissolved in hot water. The whole is thoroughly mixed by means of revolving paddles.

f. *Beating.*—The bleached half stuff is now taken to the beating engine, a machine constructed in the same manner as the *breaker*. The knives of the former can, however, be brought much closer together, and so reduces the material to a complete pulp. It is now ready to be made into paper.

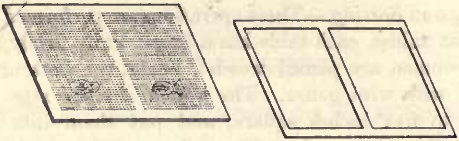
If the pulp is wanted for *toned* paper the colouring matter necessary to produce the *tone* is now added. In some cases the size necessary for rendering the paper fit for writing on is also added. Sometimes this is done after the paper has been formed.

2. *When made of other Substances.*—The treatment of *esparto grass* is much the same as that of rags. In place of the first dusting the grass is examined by girls, who remove all impurities, as sand, weeds, and root ends, and after the pulp has been fully formed a certain quantity of China clay is mixed with it for the purpose of binding the material together when made into paper.

In the case of *straw* and *wood* the materials are first cut into small pieces before they are submitted to the other processes, which are similar to those mentioned above.

Second—FORMING THE PULP INTO PAPER:

Hand-made Paper.—Paper is now principally made by machinery; but a little is still made by hand, and it is of the best quality. Bank-notes and different kinds of drawing paper are always made by hand. The following are the processes:



Paper Moulds.

The paper is made on a mould of wire-cloth, with a movable edge of wood called a *deckle* extending slightly above the surface of the mould. The wire-cloth is supported by pieces of thick wire placed beneath it.

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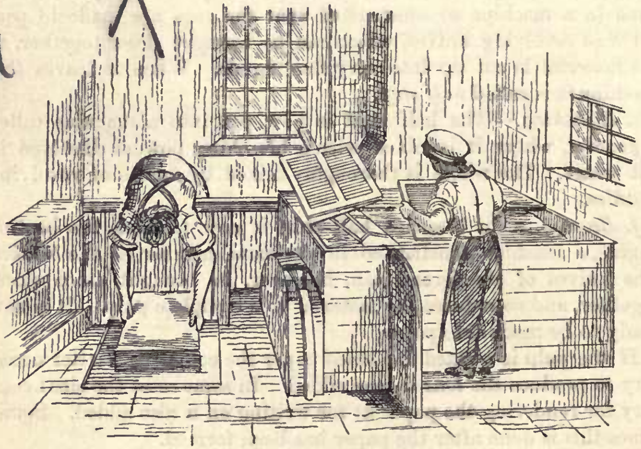


Making Paper by Hand.

To form a sheet of paper the workman dips the mould into a vat containing the pulp, lifting up just as much as will make a sheet of necessary thickness.

As soon as the mould is removed from the vat the water drains through the wire-cloth, and the pulp is left in the form of a sheet. The evenness of the sheet is secured by the skill of the workman.

The movable deckle is then taken off, and the mould given to another workman, called a *coucher*, who turns it over and presses it against a felt. By this means the sheet is transferred from the wire to the felt.

A number of sheets thus formed are piled above each other, alternating with pieces of felt, and the whole is subjected to great pressure to expel the water.

When sufficiently dried the felts are removed, and the sheets again pressed. In this state the material is like blotting-paper, and too absorbent for use.

The next operation is *sizing*. This is accomplished by dipping the sheets into a solution of gelatine. They are again slightly pressed, and then hung up separately on lines or poles to dry.

Any pattern or name required on the paper is obtained by making the wire-cloth in such a way that it is slightly raised in those parts where the pattern is needed, consequently less pulp lodges there, and the paper is of course thinner, thus showing the exact counterpart of the pattern on the mould. Whatever patterns are thus formed are known as *water-marks.*

Machine-made Paper.—Paper-making by hand is rather a slow process. Two men and a boy can make only about six to eight reams a day. At this rate there would not be sufficient made to supply the great demand, and beside this, the sheets cannot be made of any great size. At the present time by far the largest quantity of paper is made by machinery.

It is not possible to explain the construction of the machine, but by a careful observation of a picture it will be seen that the pulp is run out of the vat on to a band of wire gauze, and then it passes to a band of felt, and then on to a cylinder, and then to another, and so on, until at the end of the machine it is perfectly formed paper. And all this is done in less than two minutes from the time the pulp leaves the vat.

V. Extent of the Industry.—At the present time there are 384 paper-makers in the United Kingdom, employing 544 machines.

The imports of *raw materials* in 1891 were:

Linen and cotton rags, ...	32,110 tons,	value £317,555
Vegetable fibre (grass, &c.), ...	212,666 ,,	,, 1,033,938
Pulp of wood, ...	156,609 ,,	,, 851,389
Pulp of rags, ...	37,099 ,,	,, 258,668

The imports of *paper* in the same year were:

Printing and writing paper, ...	321,635	cwts.,	value	£397,926
Un-enumerated, ...	1,104,228	,,	,,	1,272,458
Millboard and pasteboard,.........	1,165,893	,,	,,	453,427
Paper-hangings, ...	8,222	,,	,,	45,169

The exports of manufactured paper of all kinds in 1891 were 1,003,863 cwts., the declared value of which was £1,732,594.

PART II.

COMMON ANIMALS, VEGETABLES, MINERALS, AND NATURAL PHENOMENA.

SECTION I.—FAMILIAR ANIMALS.

A. Animals used for Draught and Burden.

LESSON 60.—INTRODUCTORY. ON ANIMAL, VEGETABLE, AND MINERAL SUBSTANCES.—THE IDEA OF CLASSIFICATION.

I. Idea of Classification.—Provide a number of natural bodies, and let the children name each as held up. A small bird, a fish, a sort of grass or any other plant, a piece of leather, an apple, a bone, a piece of slate, a piece of sponge, a lump of clay, a piece of coral, a worm, a snail, and an insect of any kind, a piece of sea-weed, and several pieces of metal, &c.

Tell the children that although there are so many different objects, it is possible to arrange them into a few groups. The class to do this, one boy being allowed to act for the rest. When he has done this, the names of the objects placed in each group to be written on the slate, thus:—

ANIMAL.	VEGETABLE.	MINERAL.
Horse.	Apple.	Slate.
Sparrow.	Sea-weed.	Clay.
Fish.	Wood.	Iron.
Bone.	Potato.	Copper.
Skin.	Calico.	Marble.
Snail.	Grass.	Lime.
Fly.	Moss, &c.	&c.
Worm.		
Spider.		
Sponge.		
Coral, &c.		

Children will see that the boy has placed the objects into *three* groups. If the coral and sponge are left out, call attention to the fact, and ask him why he did so. Most likely he will say that he did not know into which group they should be put. Tell the class that this is just what you expected. There was a time when even learned men were puzzled about the same thing. It is now agreed, however, that both must be put in the same group as that in which the sparrow and the fish are placed. Add them to the first group.

II. Names.—Tell that each of the groups may be called a *class.* So all the objects on the table belong to one or other of three classes, and as they are all natural objects they are called *kingdoms of nature.*

The first is called the *animal kingdom,* the second the *vegetable kingdom,* the third the *mineral kingdom.* Write the names over each group. Tell children that had there been many more objects on the table it would have been possible to have placed them all in one or other of these groups; indeed every object in the world belongs to one or other of these three classes or kingdoms of nature.

III. Classification of the various Bodies.—Next have the **mineral substances** examined and placed in groups according as they resemble each other in substance. Call attention to what has been done. The boy has placed the iron, the copper, the lead, the tin, and the shilling in one group; the granite, the slate, the marble, and the chalk in another; the clay, the fuller's-earth, and the mould in a third. He has done the right thing.

Tell the class that if they had any number of minerals or mineral substances they would be able to arrange them in one or other of these three groups:—

METALS.	ROCKS.	EARTHS.
Copper.	Granite.	Clay.
Iron.	Slate.	Fuller's-earth.
Lead.	Marble.	Mould.
Tin.	Chalk.	
Silver.	Sandstone.	
Brass.	Lime.	

Give the proper names and write them over each column. Those in the first group are called *Metals,* those in the second *Stones* or *Rocks,* those in the third *Earths.*

Tell the class that both stones and earths are spoken of under the one term *rocks;* but for the present they may regard all mineral substances as belonging to one or other of the three classes mentioned.

There are very many kinds of metals and rocks; the study of these is called *Geology.*

Attention may next be called to the **animal group,** questioning on the difference in structure of any two, say the bird and the snail.

One has an internal framework of bone, consisting of a *backbone and certain appendages;* the other has *no such framework.* Let children examine all the other examples and compare each as to this one particular, when they will see that all can be placed in one or other of these two divisions.

Tell that those animals which have backbones are said to be *Vertebrated*, and those without such framework *Invertebrated.* The VERTEBRATED consist of *fishes*, *reptiles*, *birds*, and *mammals.* The INVERTEBRATED consist of soft-bodied creatures such as Snails and Slugs—*Molluscs* as they are called; ringed animals with three pairs of legs, as the Flies, Moths—*Insects;* ringed animals with four pairs of legs, but without wings, as Spiders and Scorpions—*Arachnida;* ringed animals with a hard covering and five pairs of legs, as the Lobsters and Crabs—*Crustacea;* ringed animals with many legs, as the Centipede—*Myriapoda;* ringed animals with soft bodies and without jointed limbs, as the Earth-worm—*Annelidan;* animals whose form is more or less rayed, as the Star-fish; and animals whose body and limbs, when they have any, are composed of a jelly-like substance, as the Jelly-fish and Polyp and Sponge Animal.

Tell children that there are many kinds of animals in each of these divisions; the study of these is called *Zoology*.

The **vegetable substances** may now be examined, and by comparing the apple-tree with a moss or fern children may be led to see that the former bears flowers, the latter does not. Other examples may be noticed, and the class led to conclude that the whole of the vegetable kingdom may be divided into two great divisions, namely, **flowering** and **non-flowering** plants.

The children may now be told that the flowering plants may be again divided into two other groups, according to the way in which the stem grows; and that the study of all these points belongs to what is called *Botany*.

LESSON 61.—THE HORSE.

I. Introduction.—Tell the subject of the lesson, and let the children say what they may have observed about the creature, thus bringing out that—

1. The horse is a large domestic animal, and is used by man as a beast of draught and burden.

2. There are several kinds of horses in this country, each kind being used for a different purpose; arrange these thus:—

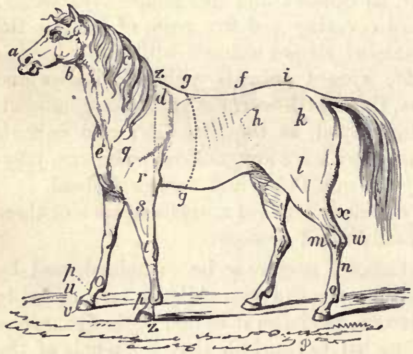
(1) Stout thick-set horses, used to draw heavy loads in wagons, drays, &c.; these called *cart-horses.* The Clydesdale and the Suffolk Punch are examples of this kind.

(2) Somewhat lighter-set horses, such as are used to draw carriages; hence sometimes called *carriage-horses.* The Cleveland horse is an example of this kind.

(3) Very slender, thinly-set horses, used for hunting and racing; these called *race-horses.*

(4) Small shaggy kinds of horse, called *Shetland ponies.*

Question children on the various colours in horses they may have noticed and arrange them into: (*a*) Bay-stock; (*b*) White or Gray stock; (*c*) Black-stock; and (*d*) Dun or Tan-stock.



Horse, showing names of the various parts.

a, Muzzle. b, Gullet. c, Crest. d, Withers. e, Chest. f, Loins. gg, Girth. h, Hip or ilium. i, Croup. k, Haunch or quarters. l, Thigh. m, Hock. n, Shank or cannon. o, Fetlock. p, Pastern. q, Shoulder-bone or scapula. r, Elbow. s, Fore thigh or arm. t, Knee. u, Coronet. v, Hoof. w, Point of Hock. x, Hamstring. z z, *Height.*

3. The male horse is called a *stallion,* the female a *mare.* The young of the horse is called a *foal,* and its mother is called its *dam.* If the foal is a male animal it is called a *colt;* if a female, a *filly.* The voice of the horse is called a *neigh.*

II. Characteristic Structure. — Enlarge diagram as given here, and lead the children to make an accurate observation of the creature, and so learn the names and character of its parts. Less or more to be given according to the age of the children.

1. *Size.* Height always spoken of as so many *hands* high. A hand equals four inches; the measurement being from the bottom of the hoof to the top of the withers. The average height of ordinary horses is about fifteen hands, or five feet; the extreme ranges being from nine to seventeen hands. The length of a horse fifteen hands high would be about seven feet three inches, measuring from the forehead to the root of the tail.

2. *Name of parts.*—The distinctive names given to the parts of the horse will readily be learned by careful observation of the above diagram.

III. General Appearance.—This to be questioned out, partly from observation of picture, and partly from children's previous knowledge. Thus work out the following points:—

The skin is covered with short hair, generally of uniform colour; when not so, the different colours mingle or are in spots—*dappled* as it is termed—never in lines. The tail is furnished with long hair up to the root. The legs are furnished on the inner surfaces with callosities on both the fore and hind limbs.

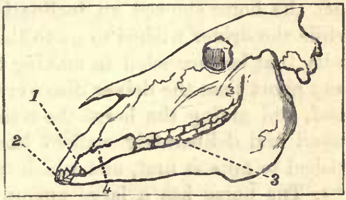
The skull is long, and the jaws especially so. The neck is arched on the upper side, gradually getting thinner from the body to the head, and furnished on the upper edge with long flowing hair called the *mane*. The chest is very broad; the shoulders slant backward, and the hinder part of the body is somewhat elevated above the middle of the back.

IV. Adaptation of Structure to food, habits, and use.—To be worked out partly by observation and partly by telling.

Food entirely vegetable. The horse when allowed to feed at pleasure is essentially a grazing animal. Hence its thin muscular lips are delicate organs of feeling, and possess much prehensile power, which enables it to crop the shortest grass. The incisor teeth are large, fitted for cutting off the herbage, and the molars strong, and so fitted for grinding. The jaws have a peculiar lateral motion, and so the upper and lower molars act as grindstones.

The *eyes* are large, and so placed as to allow of a great range of vision. Over the central surface of the iris there is a green pigment, and this enables the creature to see well in the faintest twilight. Eye-lashes on the top lid only. The *ears* are short and pointed, each can be moved separately. Sense of hearing very acute. *Nostrils* fleshy and open. Sense of smell very acute.

Show picture of skeleton of horse and compare with elephant. Former very slender, fitted for rapid movement; muscular power, however, very great. A Tartar horse travelled 140 miles a day for five successive days. An English racehorse has been known to run a mile in one minute and four seconds.



Skull of a Horse.

1, Canine tooth. 2, Incisors. 3, Molars. 4, The bar.

Show picture of bones of jaw with the teeth, and thus lead the children to see their character, and how it is that a bit can be put into the mouth and yet the creature is able to shut its mouth. In front six incisors in each jaw (2), a small space, then the blunt canines (1)—absent in the female, next a large space called the *bar* (4). This succeeded by six molars in each side of each jaw (3). It is in the space called the bar that the bit is put, and it can rub against the first molars.

The particular character of the teeth at different times in the life of the horse serves as marks by which its age can be determined. When a horse is born it has the first and second molar teeth just cut through the gum. In about a week the two middle incisors make their appearance; after five weeks the two next. When the creature is eight months old the third pair of incisors make their appearance. The enamel on these teeth is hard and thick, forming a swelling above the edge, which remains sharp. Behind the inner edge the surface is depressed and becomes dark, and this dark spot becomes a mark whereby the age of the creature is determined; for at the age of eight years all the permanent teeth are in their places, and the cutting teeth have lost their dark spots.

V. Character.—To be told.

1. In a *natural* state the horse is gregarious, and fond of companions, droves of from four to five hundred not unfrequently seen.

2. In a *domestic* state the horse will make friendships with other animals. The writer knew a horse whose favourite companion was a black cat; and both seemed to be very contented when pussy was comfortably seated on the other's back.

3. The horse has an exceedingly *good memory*. It will find its way home if it has ever been over the road before. But a few months ago the writer was riding with a friend, and coming to where two roads met the horse showed an inclination to go by the one to the right, while the driver wished to go to the left, and it was with some difficulty that he succeeded in making the animal take that path. In a very short time the driver discovered that he had chosen the wrong road, and giving the horse the reins the intelligent creature turned round and deliberately walked back, took the road which he had wished to take at first, and which turned out to be the right one.

4. The horse has a large amount of *intelligence*. In one of our vacation trips we visited a coal-mine, and was much interested in the doings of a pony which had been carefully instructed by its driver to answer certain questions. "Punch," said the youth, addressing the animal, "at what time do you like to leave off work?" The answer was given by the creature lifting the right fore-leg and stamping once, signifying that he liked to leave off at one o'clock.

The driver then said, "Do you like to work until three o'clock, Punch?" A shake of the head denoted his unwillingness to do so, and afterwards a nod of the head gave the answer in the affirmative to the next question, "Do you like to leave off at one o'clock?"

VI. The Value of Horses:

1. *Alive.*—At the present time good horses fetch very high prices, as much as £200 being given for a first-rate riding-horse; £300 or more for a good hunter, while as much as £700 has been given for a pair of well-matched carriage horses. Cart-horses vary in price according to age and condition.

2. *Dead.*—A very large number of horses die or have to be killed every week in England,—the average at the present time is 540 in London alone. Every portion of the animal is turned to account. Thus the hair is used for stuffing cushions, &c.; the hide for leather; the tendons and hoofs for glue; the flesh for cat's meat; the blood for several purposes; the fat for soap, &c.; and the bones for knife-handles, animal charcoal, &c. The average price paid for the dead carcass by the licensed horse slaughterer is 30*s*.

VII. The Wild Horse.—Although the horse has been from time immemorial the companion and servant of man, there are some parts of the world where it is still found in a wild state. Thus in Tartary it is found in herds of many thousands. The Tartars catch them both for the purpose of work and for food. From the milk they make cheese, and the flesh they cook for food. In the prairies of America immense herds of *mustangs* or wild horses are found. These are caught by the natives with a long rope with a noose at the end. The most beautiful wild horses are those of Arabia. It is from these that the English race-horse has been perfected. In the Shetland Isles a breed of small horses run in a semi-wild state.

LESSON 62.—THE ASS.

I. Structure.—Show picture, compare with horse, and work out points of difference:

1. Is a much *smaller* animal.
2. *Ears* very long and inclined outward.
3. *Skin* covered with shaggy hair, of a bluish ash colour, marked with a black stripe along the back and another across the shoulders.
4. *Mane* short and erect.

5. *Tail* clothed with short hair, but having a tuft at the end.
6. *Callosities* on the fore-legs only.
7. *Hoofs* form an oval impression.
8. *General appearance* dull, slouching, with stiff walk.
9. *Hide* dense and callous.

Other points of structure like that of the horse.

II. Character.—Question children on what they may have noticed about the behaviour of donkeys. Supply what not known, and so work out that the ass is a patient, laborious animal, though somewhat slow and obstinate when ill-treated, repelling injuries by kicking and biting, but susceptible of kindness and will repay it. When well cared for, the coat assumes a smooth and nice appearance, and the animal often exhibits traits of character which show that it is not devoid of intelligence. A pet was allowed to walk at large in a garden on the condition that he restrained himself from leaving the regular path. On one or two occasions he went over the flower-beds, and the gardener whipped him for doing so. Shortly after this he went over a bed again, and then, seemingly remembering that he was doing wrong, endeavoured to scrape the earth over the mark of his feet; this of course made the matter worse, and he paid for his fault by another whipping.

The writer once had a neighbour, whose donkey took a liking to some choice evergreens in the school garden, and in order to obtain them endeavoured to lift up the latch of the gate with his tongue. After many trials it succeeded in doing it, and on more than one occasion he helped himself rather too freely to the best twigs of the very best shrubs.

III. Use to Man.—Question children on what they may have seen the donkey eating, tell what not known, and so work out that the ass feeds on the coarsest kind of food such as the horse will pass over, as thistles, &c. It is, however, rather delicate about what it drinks. It is capable of a great amount of toil, and as its food costs very little it is most useful to the poor. Notwithstanding this, it is often subjected to much ill treatment, especially so at seaside watering-places, and by thoughtless boys at school-feasts.

Teachers should impress the children with the wrong of such acts, and interest them in the efforts of Captain Scott and the Baroness Burdett-Coutts to lead the owners of donkeys to treat them kindly.[1]

IV. The Home of the Ass.—Tell what not known.

1. The ass is found wild in Arabia Petræa, India, and Afghanistan,

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[1] See Reports of the Society for the Prevention of Cruelty to Animals.

and is a much finer animal than that which is now domesticated in the countries of Europe. In the East it is more extensively used than in the West, and is generally employed for carrying burdens or for the saddle.

2. In ancient times the ass appears to have been more swift of foot than the horse; thus Xenophon the Greek historian says: "The asses when they were pursued, having gained ground of the horses, stood still (for they exceeded them much in speed), and when they came up to them they did the same again, that is distanced the horses, so that our horsemen could take them by no other means but by dividing themselves into relays, and succeeding one another in the chase."

3. Read Scripture references to the ass, to show that its subjugation probably preceded that of the horse. Thus, as early as the time of the Pharaohs it was used as a beast of burden, Gen. xlv. 23, and in the time of Job it constituted a part of a man's wealth, Job i. 3. It was used as an emblem of strength; Issachar is compared to a strong ass crouching down between two burdens, Gen. xlix. 14; and as an emblem of peace our Lord, according to the prophecy of Zechariah, entered Jerusalem on an ass's colt,—a peaceful judge, not an earthly conqueror.

Though the Hebrews measured their wealth by the number of their asses, yet they treated them with indignity when they were dead, refusing them that burial which they afforded all other animals. Jehoiakim, King of Judah, was, as a punishment, to be buried with the burial of an ass, that is cast forth beyond the gates of Jerusalem, Jer. xxii. 19. The case was different with the heathen, who, it appears, honoured them.

Lesson 63.—THE INDIAN ELEPHANT.

Tell the subject of the lesson, and let the children say what they know of the animal, as to its use in India and other eastern countries, its peculiar structure, habits, &c. Then by the aid of diagrams work out the following particulars.

I. Its Structure.—By giving the following exact measurements of a fine old elephant which belonged to one of the Princes of Oude, and comparing them with those of the horse, lead the children to see that it is beyond comparison, the largest of all the beasts of burden:—

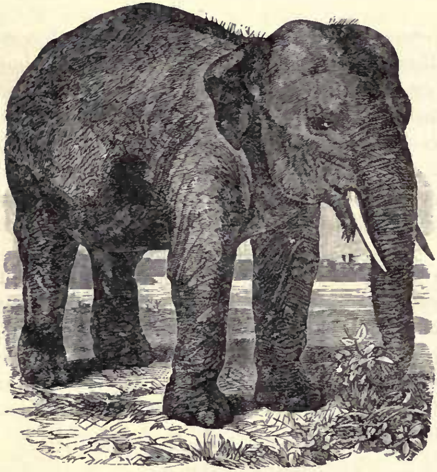
Height. From sole of foot to top of shoulder (the wither of the horse), 10 feet 6 inches = 31 hands 2 inches. From sole of foot to top of head when set up, 12 feet 2 inches = 36 hands 2 inches.

Length.—From forehead to the root of the tail, 15 feet 11 inches.

The *Weight* of such an elephant would probably be about 6 tons 2 cwts., of which 4 tons 8 cwts. would be the weight of the carcass.

Body covered with a *thick skin* of a dark brown colour, with a very scanty covering of *hair.* The *tail* is rather long, and has a tuft of coarse bristles at the end.

Compare the *bones of the legs* of the elephant with those of the horse, when children will see that the former are solid and compact, and formed more with regard to strength than flexibility. Without reckoning the joint which unites the hoof with the instep, the horse has three bones in the leg, while the elephant has but two. Hence the horse moves with a free elastic pace, the elephant with a stiff grave progression.



The Indian Elephant.

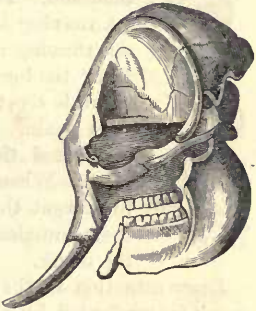
Legs further strengthened by the particular structure of the hip-joint, the ball not held in socket by a ligament as in other animals, but by the edges of the cup being prolonged so as to cover a large part of the ball, and so rendering it impossible to be forced out. When elephants lie down they extend their hind-legs backward, as a man does when he kneels; and not like the horse, which brings them under his body.

The Feet.—The pillar-like legs are supported upon broad round hoofs, terminated by five nails on the fore-feet and four on the hind. Respecting the feet the following fact may be given. Dr. Livingstone, when travelling in Africa, repeatedly measured the impressions of the fore-feet in the soft earth, and found that *twice the circumference of that impression was equal to the height of the animal.*

The writer has tested this by measuring the dried hoof of an elephant and found it borne out. The circumference of the specimen was 54 inches, which multiplied by two gives 108 inches, or 9 feet.

The Head.—Head massive, very broad in front; forehead concave and elongated, ears small and angular. By means of a diagram show that size of head is not to make room for large brain, but to protect that organ, and supply the necessary surface for the attachment of the large number of muscles which are required to support the head and move the lower jaw and trunk.

Children will thus see that the two tables of the skull are separated from each other by numerous processes. Tell that between these there are a vast number of cells communicating with the throat, and filled with air instead of the medullary substance which occupies the same space in other animals. Children will thus see that the surface of the skull is increased in size, but not increased in weight, while at the same time greater protection is given to the brain—the outer plate may be injured and the inner one remain intact. In the Natural History Museum, South Kensington, London, there is an interesting specimen of a skull, showing the number of balls which entered the outer plate and failed to penetrate the brain.



Skull of Elephant.

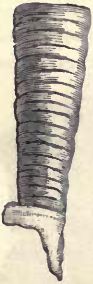
In its wild state the elephant uses its head as a battering-ram to push down the trees when the branches cannot be reached by the trunk.

The head with its appendages is of great weight, so the neck bones are compacted together, and the suspensory ligament—the *pax-wax* of the butcher—is of immense strength. In consequence of the shortness of the neck the animal is unable either to raise or depress its head so as to reach its food; and so is provided with another means of obtaining it, namely—

The Trunk or Proboscis.—Show picture and diagram of structure, tell what cannot be observed, and thus lead the children to see that the trunk is a conical tube, the upper side being convex and the under side flat. The centre is pierced by two long canals, which are the prolongation of the nostrils, and which are separated from each other by a fatty substance about the third of an inch in thickness.

At the point where these canals meet the bone of the head they are so compressed that unless there be a muscular action on the part of the animal to dilate them they remain closed, and thus operate as valves to prevent the ascent of the water which is taken in when the creature needs drink. Beyond this point the canals widen again, and continue open through the rest of their course.

By reference to the fact that the food of the elephant is found both on the ground and on trees the children will see the necessity that the trunk should be flexible and have the power of being elongated and contracted. Tell how these properties are ensured, namely by the number and disposition of the muscles, of which there are more than thirty thousand. These muscles are arranged in two sets, one set running lengthways from base to tip, and another set running across. Each set has its special use: (1) when the longitudinal muscles are contracted the whole trunk is shortened; when they are relaxed it is lengthened again. (2) When the muscles on the one side are contracted the trunk is curved on that side, and *vice versa.* When the trunk is curved the canal would close; to prevent this, (3) the transverse muscles keep it open; these muscles also assist in lengthening and shortening the trunk.



Lower Part of Elephant's Trunk.

Draw attention to the diagram, when children will see that the trunk is terminated by a flexible prolongation of the muscles into a finger, and opposed to this is a sort of thumb by which the animal holds fast any object it may wish to secure.

The uses of the trunk are fourfold: (1) To gather food. (2) To take up water, either for drink or to scatter over the body. (3) As a puff instrument, by which to scatter dust over its wet body so as to cover it with a crust which shall serve as a protection from the bites of flies. (4) The trunk also serves as an organ of touch by which the animal discovers dangers in its path. The children will thus see that the elephant's trunk is both a nose and a hand by which its food is obtained. It is a very sensitive organ, and the animal is very careful to keep it out of danger.

II. Its Food:

1. The elephant feeds entirely upon vegetable substances, and will eat grass, leaves of trees, cocoa-nuts, the fruit of the palmyra palm, the pith of the jaggery palm, and the sugar-cane. In a state of domestication it is generally fed on hay, carrots, &c., and requires about two cwts. a day. The following was the daily fare of an

elephant called Old Jack, which was the favourite of the children who visited the Zoological Gardens when the writer was a boy:—One truss and a half of hay, 42 lbs. of turnips, a mash of 3 lbs. of boiled rice, a bushel of chaff, a bushel of bran, 10 lbs. of sea-biscuits, and 36 pails of water. Every evening a truss of straw was given him for a bed, and this he used to manage to eat before the morning.

2. *The Teeth.*—In order to masticate the food the elephant is furnished with large grinding teeth, one mature tooth in each side of each jaw—four in all. These teeth grow from the back, and are pushed forward, as many as five or six being shed during the whole life of the animal. The first of these grinding teeth are shed when the animal is two years old, the second when five, the third when nine, the fourth when twenty-five, the fifth when sixty; the sixth tooth is used all through the rest of the creature's life, and when fully developed will measure fifteen inches in length by three and a half in breadth.

3. *The Tusks.*—The elephant has no canine teeth, nor any incisors in the lower jaw. The upper jaw of the male is furnished with two incisors which assume the peculiar character of tusks, in some cases attaining enormous size—a single tusk weighing 150 lbs. or more. The tusks are used to root up trees, split open palms, and as a means of defence and attack.

The elephant delights in water, and enters it freely, often remaining in it for a considerable time. It sometimes swims with its body and head under the water, the trunk being elevated above the surface so as to be able to breathe.

The elephant has an expressive *voice*, and the sounds which it utters are of three kinds. The first, which is very shrill and is produced by blowing through the trunk, is indicative of pleasure; this is called *trumping*. The second, produced by the mouth, is a low note expressive of want. The third, proceeding from the throat, is a roar, and is expressive of anger or revenge.

III. Its Character, and Use to Man.—Let the children give anything which they may know on this matter. Tell the rest, and so work out that the elephant is very docile, naturally gentle, and can be easily trained to perform all kinds of work. It has been used in India and other Eastern countries as a beast of burden and for the purposes of hunting and warfare from the earliest ages. It is always used by the chiefs to ride on whenever they go in state. On the occasion of the visit of the Prince of Wales to the Nizam eight hundred elephants were assembled to do him honour.

In 1873 the Governor-general Lord Northbrook visited Agra in state, riding on a huge elephant which had carried every successive Governor-general from Sir John Shore and Lord Wellesley down to Lord Canning. It was in 1797 that he carried Sir John Shore to Lucknow, so that if still alive the creature must be over one hundred years old.

Lesson 64.—THE CAMEL.

I. External Structure.—Show good picture, and guide the observation of the children so as to lead them to gain an accurate knowledge of the structure of the animal. What cannot be observed to be told.

1. *Size.*—Give this. Height from sole of fore-foot to the top of the hump when in good condition, from 8 to 10 feet; from forehead to root of tail, from 10 to 12 feet. Camel the largest of the ruminants.

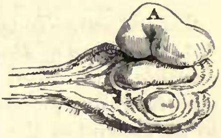
The Bactrian or Common Camel.

Children describe its general form: somewhat awkward and deformed; not at all graceful. If possible show picture of internal framework, when it will be seen that there is really no deformity.

2. The *body* is clothed with soft brown hair, which on some parts is long and tufty, while on others it is short and scanty. It is shed in flakes towards the end of spring, There are seven spots on which no hair grows; these spots are called *callosities.* They are the parts which touch the ground when the animal lies down. One is on the breast, two on each of the fore-legs, and one on each of the hind-legs. They are in the same condition when the creature is born.

3. The *head* is long, and carried in a horizontal position as regards the body. The *neck* is long and arched. The *ears* are small. The *eyes* are large and prominent, furnished with large lids and surmounted by prominent eyebrows. The *nostrils* are large and open obliquely, and can be shut at will by powerful muscles so as to exclude the sand. The senses of sight and smell are very acute. The *lips* are movable; the upper one is cleft, and is a powerful organ of prehension.

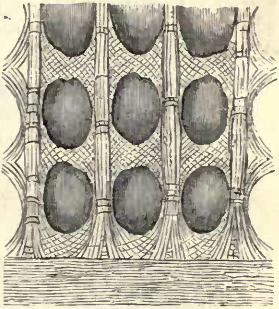
4. *Feet.*—The feet are furnished with two toes, which are united externally and attached to a soft pad or cushion which forms the sole of the foot. This pad is so elastic that when the animal walks its weight causes it to spread out and rise around the edges, so that a large surface is presented, and it is thus prevented from sinking into the loose sand. The softness of the pad gives the creature a noiseless step on every kind of path. (For structure of the foot see accompanying diagram.)



Sole of Camel's Foot, with Fleshy Cushion or Pad A *lifted.*

II. Internal Structure which fits the animal for desert life.—What cannot be worked out by examination of diagram to be told.

1. *Water Cells.*—The camel is one of the ruminating animals, and like all of that order possesses a fourfold stomach. (See lesson on the Ox.) There is, however, a remarkable alteration in the structure of some parts of that organ. The paunch is divided lengthwise into two portions or cavities by a ridge of muscular fibres. In the left cavity there are a series of cells capable of containing altogether about four or five quarts of water, and in the right a smaller series holding about a quart. By a peculiar set of muscles the mouths of these cells are drawn together and closed when filled with water, and one or more can be opened at the will of the animal so as to empty its contents and moisten the food in the main cavity when needful. By this arrangement the camel is enabled to bear the deprivation of water for several days; drinking largely at each opportunity, the cells are filled, and the animal is thus spared the agonies of thirst.



Water-cells in the Stomach of a Camel.

2. *The Hump.*—This consists entirely of a fatty substance, and is largest when the animals are in good condition. When, however, the creature is on a long desert journey, and the fare is scanty or perhaps wanting altogether, the fat which is stored up in the hump is absorbed into the system, supplying the want of food, and enabling the animal to endure the abstinence for which it is so remarkable.

By the end of a long journey the nutriment thus stored is all used up, and the hump almost entirely disappears, and it requires a long time of good feeding to restore it to its former condition.

III. Uses.—To be questioned out, or told if not known.

1. *As a beast of Draught and Burden.*—The one-humped camel or *dromedary* (so called from the Greek word *dromeus*, a runner), is used for riding purposes only. It is swift of foot and able, according to the account of the traveller Jackson, to perform a journey of six hundred and thirty miles in five days.

The two-humped camel, or caravan camel, is used as a beast of burden. This camel is able to carry an average load of 500 lbs. or 600 lbs., or even greater weights, and this for many days together travelling at the rate of fifteen to twenty-five miles in the twenty-four hours.

2. *Other Uses.*—The milk obtained from the females is used as an article of food, as is also the flesh of the dead animal. The hair is woven into coarse cloth, which is used for clothing, and the skin when taken off the dead animal is used for several purposes, as for slippers, harnesses, &c.

IV. The Home of the Camel.—To be told.

1. The two-humped camel is supposed to have been originally found in Bactria, the present Turkistan, and there to have spread over Persia and Tartary to China.

2. The one-humped camel, or dromedary, is found in Persia, Turkey, Arabia, India, and Northern Africa. It is much used on the western coast of the latter continent. There is no country where the camel is found in a wild state. Nor is there any evidence that it ever was so; it has always been the servant of man.

The Dromedary.

3. That camels were used from the earliest times in the East for the same purpose for which they are used in the present day is clear from sacred history. Thus in Gen. xii. 16 it is stated that Pharaoh gave Abram camels as well as sheep and oxen. In Gen. xxxvii. 25 we have an account of a caravan conveying merchandise as at the

present day, and from 1 Chron. v. 21 we gather that the Arabians were then the great breeders of camels. And it was doubtless through their means that the animal was introduced into Egypt and other parts of Africa. It cannot fail to interest the children to know that the camel performs the same service to-day, and is of as great importance to man as it was four thousand years ago.

Lesson 65.—THE REINDEER.

I. Introduction.—What the horse and cow are to the inhabitants of Europe, and what the camel is to the natives of Arabia, the reindeer is to the people who live in Lapland and other parts of Northern Europe, Asia, and America. The reindeer of Lapland is the best known, so the lesson will be on that animal.

Reindeer.

II. General Characters.—Show picture of tame reindeer, when children will see that it is an animal of the stag kind. Tell it is the only one of the deer tribe which has been fully domesticated and brought into the service of man. Direct the observation of the class and so help them to work out the chief points of character. What cannot be discovered tell, and so work out:—

1. *Size and Covering.*—About three feet in height; strongly built with powerful neck and shoulders. Clothed with long thick hair of a grayish colour, changing to white in the winter, but assuming a brownish appearance in summer; hair longest on under part of neck. Head and neck carried in a drooping position.

2. *Legs and Feet.*—Legs strong; hoofs large and broad, with the edges thin and sharp and deeply cleft, so spread out when brought down, thus giving them a broader surface when placed on the snow.

3. *Horns.*—If possible show picture of male and female animals and compare with other deer, when children will see that both have horns. Describe them. Those of the male are cylindrical, projecting

backwards, and curving forwards again about the middle, where there is a short branch. They terminate in many segments, which are flattened, and a single branch springs from each horn in front, which is long, branched at the end, and compressed. The horns of the females are similar, but not quite so large.

Reindeer Moss.

III. Food.—From a consideration of the climate of Lapland the children will readily conclude that the winter food must be different to that taken in summer. Tell both. In summer newly-grown herbage and shrubs, in winter the reindeer-moss, a white lichen which covers the ground thickly both under the trees and on the bare and barren ground. The animal roots for this under the snow like swine, or scrapes the snow away with its feet.

The animal makes fat very rapidly. Some killed by Mr. Lamont in Bell's Sound in the month of July were found to be lean, while those killed at the end of the following August were covered with two inches of fat.

IV. Uses to the Laplanders.—What not known to be told.

1. WHEN ALIVE:

(1) *As a beast of Draught and Burden.*—When broken in, the animal is very docile, and will proceed at a long steady trot with but little direction. The average speed with a load of 240 lbs. is about ten miles an hour. Instances are on record of a greater speed being attained, 150 miles being accomplished in nineteen hours including stoppages. The greatest recorded instance of the speed of this animal is that of a deer of which a portrait, together with that of its driver, is preserved in the palace of Drottingholm. In consequence of the Norwegians making a sudden irruption into Swedish territories an officer was despatched with a sledge and single deer to convey the intelligence to Stockholm. The distance, 124 Swedish, or 800 English miles, was performed in 48 hours; but the deer dropped down lifeless on its arrival.

Sometimes the reindeer is used to plough and harrow in the summer, and in the winter to draw hay and fodder laden upon trays.

(2) *To supply some of the necessaries of life.*—A Laplander is considered rich or poor according to the number of reindeers he possesses. If a man possesses a herd of from three to five hundred he is considered rich, for then he can with the milk obtained from the females

make a sufficient quantity of cheese for the year's consumption, and in the winter can afford to kill enough to supply him and his family pretty constantly with venison. Mr. Lamont, when speaking on this subject, says: "I think the flesh of the reindeer is the richest and most delicious meat, wild or tame, I ever tasted."

2. When Dead:

(1) For flesh-meat as above stated.

(2) To supply the necessaries of life. The skin is made into articles of clothing and covering for tents; the fat supplies fuel for lamps; the bones are made into spoons, needles, &c.; and the sinews into thread.

B. Animals used for Food.

Lesson 66.—OXEN.

I. Introduction.—Children to name the animals which in this country are used for food. Arrange them into three classes—mammals, birds, and fish. Take up the mammals. Children mention those they know, as oxen, bullocks, cows, sheep, pigs, deer, rabbits, hares. Tell that each of these will in their turn be taken up, and first *the oxen.*

II. Structure:

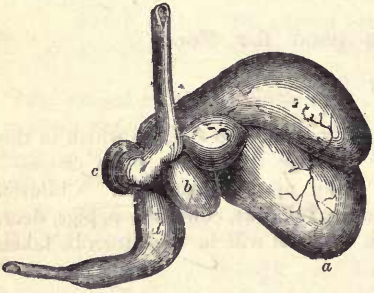
1. *Size.*—As children will have seen both bullock and cow, they will know that the oxen are large animals. Give the exact size. The following were the dimensions of an Hereford prize ox sold a few years ago. The animal was four years old. Height, from bottom of hoof to top of shoulder, 4 feet 9 inches; length, from forehead to root of tail, 7 feet 1 inch; girth behind the shoulder, 8 feet 4 inches. *It weighed 76 stones, or 1064 lbs.*

2. *Build.*— Animal thickset. Head small for size of creature. Muzzle square; forehead flat; eyes large and mild. Neck short and thick, and breast broad and deep. Skin covered with smooth, short hair. Tail long, and furnished with tuft of hair. Legs rather short, and terminating in two toes, shod with hoofs, the inner surfaces of which are flat, and fit closely together, as though a single hoof had been split into two down the middle, thus giving them the name *cloven-footed.* Behind these hoofs are two small rudimentary toes, which do not touch the ground.

III. Food and Habits.—Most children know that the oxen feed upon grass and other vegetable substances. So lead them to see clearly:

1. *How the food is gathered*, illustrating by means of diagrams. The grass is collected and rolled together by means of the long and movable tongue, the fleshy, mobile lips assisting in procuring the substance. The grass thus collected is firmly held by the lower cutting teeth against the pad (or gum) of the upper jaw, and then by a sudden nodding motion of the head the little roll of herbage is either torn or cut off. The food thus gathered is swallowed, but is not digested at once, as is the case with the horse and other animals.

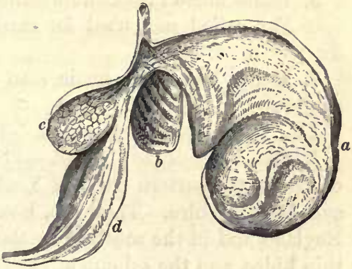
2. *The Operation of Ruminating.*—Many children will have seen the oxen lying in the fields quietly masticating their food—chewing the cud. Explain the operation, showing diagram of the four stomachs. After the food has been gathered and roughly bruised by the molar teeth it passes onward, and is swallowed, entering into the first stomach, or *paunch a* (the *rumen*). The paunch of an adult ox is very large, and will hold from 15 to 18 gallons. The food gradually passes from the paunch into the second stomach, which is small, and has its inner surface covered with regularly-formed cells, resembling the comb of the honey-bee, from which it has received the name of the *honey-comb bag b* (*reticulum*). In this bag the herbage received from the paunch is made up into small pellets or cuds.



External View of Stomachs of Ruminant. a, Paunch. b, Honey-comb bag. c. Many-plies. d, Rud or true stomach.

When the animal is at rest these pellets are forced up, one at a time, into the mouth, where it is thoroughly masticated. To enable this to be done the lower jaw, instead of possessing only vertical motion, like that of the cat and dog, is articulated to the other in such a way as to allow it great play; the muscles by which it is worked give it a grinding action, and the food being guided by the tongue and cheeks between the surfaces of the molar teeth is bruised and triturated as corn between the millstones.

When the cud has been thoroughly masticated it is again swallowed, and passes along a channel into the third stomach. This organ is small, globular, and internally consists of a number of folds which lie alternately, a broad and a narrow one with their doubled edges together, like the leaves of a book which is uncut. This third stomach is called the *many-plies c* (*omasus*). The food on being received from the mouth is here formed into flattened portions by the action of the folds, and are gradually passed onward into the next stomach, the fourth, called the *rud*, *reed*, or *rennet d* (*abomasus*). It is in this that the true work of digestion is carried on.[1]



Internal Structure of Stomachs of Ruminant.

In the calf, while sucking, there is a beautiful instance of adaptation of structure to the altered circumstances. While the creature lives on milk the functions of the first three stomachs are unnecessary, as the fluid requires no preparation for digestion. The milk, therefore, on being swallowed, is conveyed at once into the fourth stomach, which at that period of the creature's life is larger and more capacious than the other three put together. As soon, however, as the calf begins to feed upon solid food the process of rumination commences, the first three stomachs are called into action, and as the quantity of solid food is increased the paunch gradually enlarges its capacity until it reaches the full dimensions.

III. Uses.—Most of these will probably be known. Supply what may be necessary, and so work out the following facts:

1. In Palestine and other eastern countries, for agricultural purposes, in which its strength, its patience, and docility make it a most valuable helper to man. One of the earliest purposes to which it was put was for threshing corn with its feet; hence the command, "Thou shalt not muzzle the ox that treadeth out the corn." It is still employed in some parts of England for drawing the plough.

2. Cows are valuable for the sake of the milk which they give. Some fine breeds when in full milk give as much as 14 quarts at the morning milking and 10 quarts at the evening milking. Refer to lesson on MILK and its products.

July 21. D.

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[1] The same structure is found in all the animals of the order Ruminantia—sheep, camel, deer, &c. When speaking of those animals the teacher can refer back to this lesson.

3. When killed. Flesh called *beef*, a valuable article of food. Flesh of calf called *veal*.

4. Skin made into leather. See lesson on LEATHER.

5. Bones made into knife-handles, &c. See lesson on BONE.

6. Fat, called *suet*, used for many purposes. See lesson on SOAP, &c.

7. Horns and hoofs made into combs, &c. See lesson on those subjects.

IV. Principal Varieties.—If possible show pictures of these.

1. *The Short-horned Breed.*—These are principally found in Lincolnshire, the eastern parts of Yorkshire, Durham, Northumberland, and Berwickshire. They are, however, found in other counties of England and in the south of Scotland. They have smooth skins and thin hides, and the colours of the hair are red and white.

2. *The Long-horned Breed.*—These are rather smaller than the short-horned, have a thick, firm hide, long hair, and remarkable for their long horns. They are found in Lancashire and Leicestershire.

3. *The Devon*, or *Middle-horned Breed.*—These are of a red colour, with very thin hides and silky hair.

4. *The Suffolk Duns.*—A small breed, destitute of horns, and having dun-coloured hair.

5. *The Alderney Breed.*—A handsome race, with slender limbs. They are of a light-reddish or yellow colour, sometimes black. They are kept for the richness of their milk.

6. *The Galloway Breed.*—These are destitute of horns, were brought originally from Galloway, a rather wild district in the south of Scotland. They are now the most common cattle in that district and Dumfriesshire, where they are reared and grazed for a year or two, and then sent to Norfolk and Suffolk to be fed for the London market. The beef from these animals is considered of the finest quality. The common colour of this breed is black, but red or dun is sometimes met with. The hair is rather long, but fine and silky.

7. *The Kyloe*, or *Highland Cattle.*—This breed is found in the whole of the Highlands and Western Isles of Scotland. They are horned, and are covered with black or brown hair, which in their native pastures is shaggy.

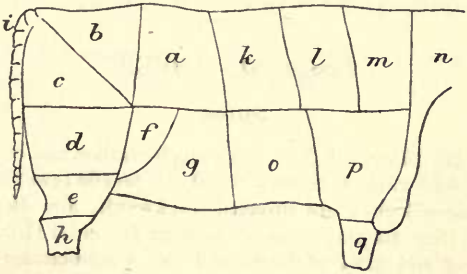
V. The Value of an Ox, and how determined.—The farmer who rears oxen generally sells them to the cattle-dealer, and is entitled to receive the value of the entire weight of beef and bones at the current price, and the profits of the purchaser are confined to the value of the offals, which consist of skin, head, entrails, and loose fat, which together are reckoned to be worth one-fifth of the value of the ox. From this the children will see that there must be some method of determining the weight. Tell how this is done.

The Live Weight.—This, of course, can be found by placing the animal on a weighing machine. But this not always convenient, and if done would not show the farmer how many pounds of beef and bone there are in the animal. So two modes pursued:

(*a*) If the animal is weighed, then that weight divided by decimal ·605 if a fat ox, or ·55 if lean, will give the *nett weight.*

(*b*) The nett weight can also be ascertained by measuring the body. Draw diagram and explain. Measure with a tape line from top of shoulder to tail head, which gives the length; then measure round the body immediately behind the fore leg, which gives the girth. Multiply the square of the girth in inches by the length in inches, and divide the sum by 7238. The quotient is the weight in stones of 14 lbs. to the stone. *Example:* Suppose an ox to be 5 feet in length and 7 feet in girth. Now girth = 84 inches × 84 inches = 7056 inches, which × 60 inches = 423,360 inches, which ÷ 7238 = 58 stones 7 lbs. Repeated trials on a number of oxen of same weight and age in the relative proportion of live and dead weight, give for every 100 lbs. of live weight, butcher meat 57·7 per cent., tallow 8 per cent., hide 5·5, and offal 28·8; total 100.

VI. How an Ox is Cut Up for Market, and the relative value of each kind of joint. Show diagram, and give the name of the joints and the value of each as food.



In Hind Quarter.—a, Loin. b, Rump. c, Aitch-bone. d, Buttock. e, Hock. f, Thick flank. g, Thin flank. h, Shin. i, Tail.

Fore Quarter.—k, Fore rib. l, Middle rib. m, Chuck rib. n, Clod steak or neck. o, Brisket. p, Leg of mutton piece. q, Shin.

1. The ribs keep best, and with care can be kept five or six days in summer, and in winter ten.

2. The middle of the loin is the next best, and the rump the next.

The round will not keep long unless salted. The brisket is the worst, and will not keep longer than three days in summer and six in winter.

3. Loin principal roasting piece; rump favourite steak piece; aitch-bone favourite stew; buttock, thick and thin flank, boiling pieces; hock and shin, soup.

4. Tail favourite soup. The following particulars respecting ox-tails may interest the class:—When in order to enlarge the Bank of England it was required to pull down the Cock eating-house in Threadneedle Street, the question of compensation was brought before the law court. At the trial evidence was given to show that in three years, 1837–38–39 there had been 13,359 ox-tails used for soup; and as 35 tails made 10 gallons of soup, there had been served up 59,360 basins at 11*d.* the basin, making the large amount of £2720, 13*s.* 4*d.* for this article alone.

5. The fore rib, middle rib, and chuck rib are roasting pieces. By removing the shoulder-blade in the middle rib the spare rib below makes a good boil or roast. Neck used for soup. Brisket boiled. Leg-of-mutton pieces stew. Shin, soup, but hind shin the best.

The number of oxen reared in this country is not sufficient to supply the demand, and so very many are imported. Thus in 1891 the total number of animals of the oxen family was 507,407, the declared value of which was £8,581,574. In the same year the value of the beef imported was £4,038,495.

Lesson 67.—SHEEP.

Notes.

1. *Compare Sheep with Ox.*—Very much smaller, and covered with wool. In some kinds both male (ram) and female (ewe) have horns. When possessed they are directed backwards, and then spirally forwards. (See diagram of ram's head in lesson on Horn, Part I.) The number and kind of teeth, and the construction of jaw, the same as in the oxen, as is also the form of the feet.

2. *Food.*—Wholly vegetable; grass gathered by lips, nibbled off by use of incisor teeth and upper lip. Structure of stomach and process of rumination the same as in oxen.

3. *Habits.*—Gregarious, timid, inclined to go astray. Where one leads rest of flock will follow. Like oxen gather food until paunch full, then lie down to ruminate.

4. *Uses.* When alive, fleeces cut off once a year for the sake of the wool. See lesson on Wool. When dead, flesh called *mutton* for human food. Fat called *suet* for butter and candles. Skin for leather. Bones for various purposes. Hoofs for glue. See lesson on those subjects.

5. *Various Kinds:*

a. Southdowns. Fleece short and fine; no horns; face and legs dark or blackish gray.

b. Leicesters. Fleece long; no horns; face white; legs thick, long, and white.

c. Dorsetshire breed. Mostly horned; those of the male, however, larger than those of the female. Wool fine and short; face white; legs small and white.

d. Highland breed, Welsh. Mostly spiral horns; wool long and shaggy; face black; a wild-looking eye; legs black.

e. Merino. Horns on male only, and rather small wool; very fine; face and legs white.

f. Cheviot breed. No horns; wool moderately long; face and leg white.

6. *Scripture reference.*—Of all our domestic animals the sheep is that of which we have the earliest notice; hence we read in Gen. iv. 2 that "Abel was a keeper of sheep." It was one of the clean animals, and was used for sacrifice, and on account of its habit of wandering from its fold was used as a figure of man's proneness to depart from God's command. "All we like sheep have gone astray," &c.

The number of sheep and lambs imported in 1891 was 344,504, the declared value of which was £663,015.

Lesson 68.—THE COMMON STAG OR RED DEER.

Notes.

I. Introduction.—The red deer is a ruminating animal; its flesh when dead is called *venison.* The male is called a *hart,* the female a *hind.* It is still found wild on Exmoor and in the forests of Scotland.

II. Structure:

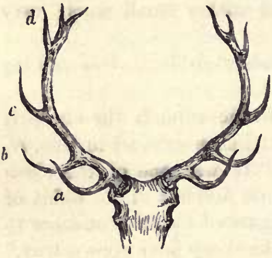
1. *Size.*—From sole of fore-foot to top of shoulder, four feet six inches. The length of head is eighteen inches; that of the neck and body five feet five inches.

2. *The body* is rounded; the neck of moderate length; the head tapering to a squarish muzzle; the eyes large and full; the ears rather long and pointed; the limbs slender; hoofs small, the tail short.

3. The skin covered with fur, which consists of both bristly and woolly hairs. Each of the long hairs is spirally twisted. The hair is longest on the buttocks and back, and more especially on the fore part of the neck; very short on the feet and muzzle.

4. The general colour of the body is yellowish-red mixed with dark brown. Along the ridge of the back the colour is darkest; the hind part of the body nearly white.

5. The horns, *which are found only in the male*, are round, with branches growing from the inner side, and all of them sharply pointed. The horns, or antlers as they are called, are solid, and are shed every year. About the end of February, the horns being loosened from their attachment to the skull, drop off, leaving two round bony scars of the diameter of the horn. In about a week after they are shed these scars are covered with a thick soft velvety skin, an extension of the skin of the head, forming two round protuberances. These gradually increase in size, and by degrees the antlers are fully developed. The time occupied in the growth is usually about sixteen weeks. Directly the horn has attained its full growth a ring of bone, called the *burr*, commences to grow around its base until it attains at least double the diameter of the horn. The expansion of this ring gradually stretches the velvet which covers it, compressing the blood-vessels contained in it, and shutting off the flow of blood from the arteries; thus deprived of its vitality, the skin gradually dies, shrinks from the bone, and peels off in strips, leaving the bony antlers complete.



Antlers of the Red Deer.

a, Brow-antler. b, Bez-antler. c, Antler-royal. d, Sur-royal or crown-antler.

The antlers are only gradually developed in size and in the number of their points. During the first year of the animal's life it has no horns; in the second year they appear as short straight points; but one or two new points, or *tines* as they are called, are added after each shedding until about the seventh or eight year, when the increase is irregular; but the tines seldom exceed ten or twelve in number. The different tines receive special names, as seen in the diagram. This process takes place in every kind of deer, and, with the exception of the reindeer, the males only have horns.

III. Food.—Entirely vegetable; graze in the same manner as sheep. Arrangement of teeth and structure of stomach same as other ruminating animals. See lesson on OXEN.

IV. Habits.—Gregarious; found in the forests of Scotland. Feed chiefly in the morning and evening; during the greater part of the day repose among the heath. Very wary; have a very quick eye; catches sight of the smallest object in motion. Sense of smell so acute that it can detect the approach of a human being long before he can be seen; hence the difficulty of the sportsman to get near enough to reach the animal with his gun. If wounded and chased the stag turns to bay in some stream or pool, and is then a most formidable antagonist, charging his assailant with the utmost fury, and often inflicting very serious wounds.

In the summer the males keep apart from the females, feeding singly or in small herds, the does with their young preferring the valleys.

V. Uses:

Flesh, as food—*venison.*
Skin. Best leather for gloves.
Antlers. Knife handles.

VI. Other kinds of Deer:

1. *The Fallow deer.*—Not found wild in Britain, but is common in most of the countries of Europe. Size about three feet high. There are two varieties kept in the parks of England; one covered with dark brown hair, another with brownish yellow hair on the sides, being distinctly dappled with spots of white. The horns are round at base with a sharply-pointed brow antler. Above this they gradually become flat, and terminate in a long and broad palm, the outer edge of which is notched with numerous small projections. The fallow deer in our parks become very tame, and will approach those they are accustomed to see to be fed.

2. *The Roebuck.*—The smallest and most beautiful of the British species. Height at shoulder about two feet to two feet six inches. Length of body about two feet six inches. It is one of the most elegantly formed of our native quadrupeds. The limbs are long and slender, the neck of moderate length and rather thick; the head tapering; the muzzle rather narrow; the eyes large; the ears long and pointed. The colour of the hair in winter is brown with a tinge of gray; in summer a bright reddish-yellow. The horns are only

eight to nine inches long, and when full-grown branch into three points. The roebuck is not gregarious, but assembles in family parties in the woods and plantations.

Lesson 69.—THE PIG.

Notes.

I. Structure.—Show picture of common hog. Direct attention to—

1. *Its form*. Body nearly cylindrical; legs short; head placed upon the same line with trunk.

2. *Head* pointed; nose ending in snout furnished with strong cartilage at extremity and with powerful muscles, which render it flexible.

3. *Mouth* furnished with powerful teeth; the canines of the male fully developed, and form tusks for defence.

4. *Legs* short; each foot furnished with four toes, the two front ones cased in horn, and cloven. But animal not one of the ruminants.

5. *Skin* thick, and covered with strong hairs called bristles, which are thinly planted, and often have an under fur of fine curly hair. This is, however, sometimes wanting.

6. *Tail* short, and generally twisted.

II. Food.—What not known to be told. If able to get them, acorns, beech-nuts, but when pressed with hunger will eat any kind of food, and not at all particular, hence the refuse of the table put into the wash-tub for the pigs. Has the sense of smell in a very great degree, but the sense of touch not much developed.

III. Habits.—When kept in a sty sluggish and dirty, but when in a wild state as clean as any other animal. When let loose will grub up the earth in search of roots.

IV. Uses:

1. *Flesh* for food—called *pork*. Considered to be in season during the winter months.

2. *Bristles* of wild boar used for the hair of brushes.

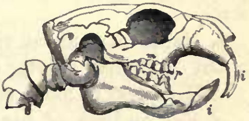
3. *Skin* in some cases taken off and turned into leather. More generally, however, the skin is not taken off, but is cooked with the meat. When roasted until done brown it is called the crackling.

Lesson 70.—HARES AND RABBITS.

Notes.

I. Points in which both are alike:

1. *Teeth.*—Both are gnawing animals—rodents—distinguished by the peculiar structure of the teeth. Children examine diagram of one of the rodents, and so discover the character of the dentition, namely, two long cutting teeth—incisors—in front of each jaw. These have sharp, chisel-shaped edges. The inner side of each tooth is soft, outer is covered with hard enamel. These teeth continue to grow during the whole period of the life of the animal, but are kept the proper length by the continual rubbing of their edges in the habit of gnawing, and are kept in shape by the same habit.



Skull of the Marmot.
i, Incisors. p, Premolars. m, Molars.

The curve of these teeth is a segment of a circle, and the sockets in which they are held pass into the jaws, where they terminate in a pulp cavity in the same manner as the tusks of the elephant. They have, therefore, no fangs, and continue growing during the animal's life. The substance of these teeth is comparatively soft, and is covered on the front only with a hard enamel. In consequence of this the inner part wears away faster than the outer, and thus they always have a sharp edge, like a chisel; they are also kept at a proper length by the habit of gnawing. The tendency to grow is so powerful, that, if by accident one of the teeth should be lost, the opposite tooth, having nothing to wear it away, continues to push forward until it often causes the injury or death of the animal. Immediately behind the two large incisors in the upper jaw there are two smaller ones, but these are not used; they serve to distinguish the hares and rabbits from other gnawing animals, as the rats and mice, &c. There are no canine teeth. The premolars and molars are rootless, and are together six in number on each side in the upper jaw and five in the lower.

2. If any child present who has kept rabbits, question as to character of lips and feet. If not known tell. Upper lip cleft, and each half movable. There is a tuft of hair on the inside of the cheeks.

3. In both the hind legs are longer than the fore. Both have four toes on the fore feet and four on the hind. The soles of the feet are hairy.

4. Senses of sight and hearing very acute. Eyes placed at the side of the head, and have great range of vision.

5. Ears movable; lie down when at rest; can be turned to catch sound behind.

II. Points of Difference:

1. *Structure:*

a. Hares larger than rabbits—former 2 feet 4 inches, latter 1 foot 8 inches.

b. Hares' ears about the same length as the head; rabbits' ears about one-fourth shorter than head.

c. Hind legs of hares much longer than those of rabbits.

d. Fur on back of hare yellowish-brown, mixed with black, and curly; abdomen of a whitish tinge or gray. Fur of the rabbit uniformly brownish-gray; throat and lower part gray. Fur not curly.

2. *Habits:*

a. Hares live in slight hollow of ground called a *form,* generally surrounded with grass or fern. Rabbits make long winding burrows, in which they live during the day, coming out in the early morning and in the evening and night to feed. Never wander very far away from the burrow, to which they retreat on the approach of danger. Burrows made in sandy soil.

b. Rabbits gregarious. Form their burrows near each other, such an assemblage being called a *warren.*

c. Flesh of hares of a dark colour, that of rabbits light.

d. Hares are called *game,* and are sometimes hunted by dogs—greyhounds—who pursue them by sight. This kind of hunting is called *coursing.* Rabbits are not game.

e. Rabbits are reared for market both in natural warrens and in artificial ones. Immense numbers are imported from Ostend every week during the season. These are all skinned before they are sent to market. The dead animals are sold by the pound. Wild rabbits are sent to market with the skins on, and are sold at a certain price per animal.

The skins of both hares and rabbits are valuable for the fur. See lesson on FUR.

LESSON 71.—BIRDS USED FOR FOOD.

I. Introduction.—Let the children name the birds which they may have seen for sale in the poulterers' shops. Arrange them into two groups—poultry and game, the former consisting of fowls, turkeys, pigeons, ducks, and geese; the latter of pheasants, partridges, and grouse.

Question out or give the times of the year when each is considered in season.

II. The Poultry Birds:

Fowls.—Show pictures of common cock and hen, and provide specimens of the head and feet of either or both. By questioning on these work out the following points of structure:—

Body rather large and of a stout and somewhat heavy appearance. Head rather small; bill of moderate length and very strong; the upper mandible arched to the tip and vaulted; the nostril placed in a large membranous groove and protected by a scale.

Wings of moderate size, concave, and somewhat rounded; the tail compressed and arched. The bone of the leg to which the toes are attached, the tarsus, rather long and strong. Three toes in front and one behind, all long and strong and armed with blunt nails. The three front toes united at their base by a membrane; the hind toe elevated a little above the ground.

The male bird distinguished from the female by being larger, having a much more beautiful plumage, the middle feathers of the tail being longer than the others, and falling over them in a graceful arch; by the presence of fleshy wattles on the head and under the base of the bill; and by strong spurs on the tarsi.

III. Habits and Food.—Children who live in rural districts or whose parents may have kept fowls will know some of the habits of these birds. Let such give what they may have observed. Supply what not known, and so work out that fowls are ground birds, seldom taking to the wing unless very much pressed by their enemies. They are social birds, and live in societies consisting of one cock and a number of hens.

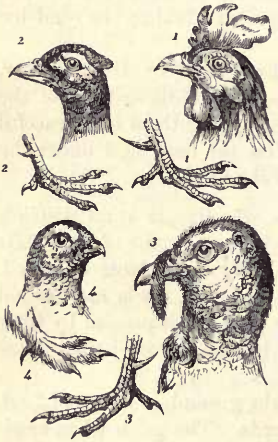
They spend the day in scratching up the ground in search of food, which consists of insects, worms, and seeds. The grain when swallowed passes into the crop, and from thence into the gizzard, which is a strong muscular organ fitted for grinding the hard seeds. In order to assist in the process of grinding the birds swallow small stones or other hard substances which may come in their way. In the evening they roost on perches.

The hen, unless trained to go into a nest prepared for her, lays her eggs upon the ground in some sheltered situation. After laying her eggs she utters a loud cackling cry, to which the cock responds in a high-toned kind of scream. She sits upon her eggs for twenty-one days. The young leave the egg both fledged and able to run and feed themselves.

When a hen has a brood of chickens she calls them by a peculiar clucking note, and is particularly fearless and devoted to their defence. At night or on the approach of danger the brood shelter themselves under the wings of their mother—a habit to which our Lord referred when He, speaking of Jerusalem, said, "How oft would I have gathered thee as a hen doth gather her brood under her wings."

IV. Use of Fowls.—Fowls are kept for the sake of their eggs as well as for their flesh. Although few hens incubate oftener than once a year, they will, if properly fed, continue to lay eggs during the greater part of the year. As many as 200 eggs have been laid by one bird. See lesson on EGGS.

The common fowl is supposed to have been derived from the Javan fowl of India, but at what time and by what people it was introduced into England is not known; but it must have been at a very early date, as its flesh is among the things forbidden by the Druids as food.



Rasores or Scratching Birds.

1, Head and Foot of Jungle-fowl. 2, Do. of Common Pheasant. 3, Do. of Wild Turkey. 4, Do. of Common Grouse.

V. The different Breeds of Fowls.—Country children will probably know some of the various breeds kept, but the majority of those who live in large manufacturing towns will not, so show pictures, and work out the description of the principal kinds.

1. *The Dorking Breed.*—Distinguished by having a large rounded body, with short legs, with one or more additional imperfect toes. The plumage is white. The flesh is remarkable for whiteness and delicacy of flavour.

2. *The Spanish Breed.*—These fowls are of a very large size. The plumage is black, the comb large, and often pendulous, and the naked skin behind the ear white. The hens lay very large eggs, but do not sit well.

3. *The Poland or Hamburg Breed.*—There are several varieties of this breed: (*a*) The black Poland, distinguished by having a large top-knot of long white feathers; (*b*) the gold-spangled; and (*c*) the

silver-spangled Polands. These have small combs on the front part of the head, and a full top-knot of feathers on the crown.

4. *The Game Breed.*—These fowls are distinguished by their brilliant plumage, especially that of the male birds. The flesh is delicately white, and of the finest flavour. The pugnacity of these fowls is very great, rendering it troublesome to rear them, and cases have been known of a whole brood of young game chickens being more or less injured, and some killed on the spot, from fighting among themselves.

5. *The Bantam Breeds.*—These are the smallest of all the fowls. One breed resembles the game fowl, excepting in size. Another breed is feathered to the very toes, the feathers on the tarsi being long and stiff, and often brushing the ground.

6. *The Cochin-China Breed.*—These are large, tall, ungraceful birds, with small tail and wings. Plumage of a yellowish-brown colour; feathers on the legs extending to the toes.

LESSON 72.—THE TURKEY.

I. Structure.—Show pictures of male and female birds, compare with fowls, and work out the resemblances and differences. General form similar, structure of feet and bill the same.

Differences.—Much larger birds, some have been known to weigh 30 lbs. The head is bare, and the bill of the male surmounted with a conical fleshy appendage which becomes inflated when the bird is excited by passion. The neck is wattled, a tuft of long hairs springs from the base of the neck of the male, and hangs down on the breast.

The tail is broad and rounded, capable of being erected and spread out; and this the male is in the habit of doing when he struts about with wings rubbing on the ground uttering his loud peculiar gobble.

The general plumage is of a beautiful metallic lustre.

II. Habits.—Turkeys are birds of rambling habits: they delight to wander in the fields in search of insects, seeds, and fruits. A troop will ramble about all day, returning to roost in the evening. The male bird is very pugnacious and very hardy. The hen lays early in the spring, the number of eggs being considerably more than she can sit upon; she does not, however, like the fowl, continue to lay all through the year.

The turkey is a native of northern parts of the Continent of

America, and was at one time found in great numbers in the woods extending from the north-western boundaries of the United States to the Isthmus of Panama. It appears to have been introduced into Europe in the middle of the sixteenth century. Great numbers were kept in Richmond Park in the first half of the eighteenth century.

LESSON 73.—PIGEONS.

I. Structure.—As most children have seen pigeons, and the parents of some may have kept them, it will be easy with the aid of pictures, and questions on what has been observed, to work out the distinctive characters of the bird.

1. The upper mandible of bill consists of a horny portion in front, which is long and strong; the base is formed by a cartilaginous plate in which the nostrils are situated. The skin which covers this plate is soft.

2. The legs are short; the three front toes are not united at their bases, and the hind toe is on the same level as those in front. The sole of the foot is formed of soft pads which are somewhat wider than the upper part of the toes.

3. The wings are long and pointed; the quill feathers of both wings and tail are strong, so the power of flight is great. Mr. Yarrell mentions one case in which a carrier pigeon flew from Rouen to Ghent, a distance of 150 miles, in one hour and a half.

II. Habits.—Question on what may be known; tell the rest.

When wild they perch on trees, but seek their food on the ground; they can walk and run without difficulty. Pigeons are remarkable for their mode of drinking, in which they differ from all other birds. Instead of taking up a portion of water, and then raising the head to allow the water to run down the throat, pigeons dip their bills into the water and take a long continuous draught like quadrupeds.

Both male and female birds assist in the construction of a rude nest, in which the female deposits two eggs, on which the male and female sit in turn. The young are hatched blind, unfledged and helpless, and require the care of the mother bird even for some time after leaving the nest.

While very young they are fed by the mother bird placing her beak in the open mouth of the young, and by means of a voluntary action transferring nourishment from her own crop into that of the nestling. What is transferred is (according to the investigation of

Sir John Hunter), not softened grain as some have supposed, but a special milky substance which is secreted in the crop of the parent. Sir John says, "The young pigeon is fed for some time with this substance only, and about the third day some of the common food is found mingled with it; as the pigeon grows older the proportion of common food is increased, so that by the time it is seven, eight, or nine days old, the secretion of curd ceases in the old bird, and of course no more will be found in the crop of the young one."

III. The Principal kinds of Pigeons:

1. *The Ring-dove or Wood-pigeon.*—This bird is common in England, and is known by its soft complacent cooing,—*coo-goo-roo, coo-goo, roo-o-o-o,* is a constant sound to be heard in the woods during the breeding season and even all through the summer.

The food of these birds consist of young leaves and seeds of various kinds according to the season of the year. In the spring and summer they subsist principally on the tender leaves of growing plants. As the season advances they visit the cornfields, especially those near the woods in which they live. At the approach of autumn they assemble in small flocks and resort to oak and beech woods, where acorns and beech-mast afford them an abundant diet.

2. *The Rock-dove.*—In a state of nature this bird is found on all our rocky coasts. It lives and breeds entirely in the holes of rocks. Its food consists of grain and several species of snails. This bird is the original of most of our domestic varieties which are kept as fancy birds by many people in all parts of the country.

In the East generally, pigeons from the earliest times have been great favourites and kept in multitudes. The allusions to doves and pigeons in Scripture are numerous, and show that they were equally common and equally valued in ancient times. A traveller in Egypt says that incredible numbers of these birds are kept, and in the villages, the dwellings made for them are at the least as conspicuous as those which man builds for himself.

In Persia pigeons are kept not only for the sake of their flesh, but also for their dung, which is found to be the best manure for the melons, a fruit that is indispensable to the existence of the natives during the great heats of summer. This may serve to throw some light upon the somewhat difficult passage in 2 Ki. vi. 25.

LESSON 74.—GAME BIRDS.

I. Comparison with Poultry Birds.—Show pictures of pheasant, partridge, and grouse, and compare with hen and turkey as to structure of bill and feet, wings and general shape of body, when the children will see that they resemble each other in these particulars.

II. General Character of the Pheasant.

1. THE MALE BIRD:

a. Colour of the Plumage.—If possible, show a coloured picture, and direct the children's attention to the colours in various parts; supply what cannot be found out, and so teach the following points respecting the bird. The head and neck are of a steel blue colour reflecting brown, green, and purple in different lights; the back and wings have a mixture of orange red, black, brown, and light yellow; the breast and belly are of golden red, each feather margined with black, and reflecting tints of gold and purple.

b. The Tail.—This is long, graduated, and composed of feathers which overlap each other like the tiles of a house. The middle feathers are considerably the longest. The whole length of the bird is three feet, of which the tail often measures two feet.

The tarsi are furnished with spurs.

2. THE FEMALE BIRD:

a. Colour of the Plumage.—This is of a pale yellowish brown, varied with darker brown; the sides of the neck tinged with red and green.

b. The Tail.—This is similar in form to that of the male, but much shorter. The entire length of the bird is two feet.

In both birds the cheeks and skin surrounding the eyes destitute of feathers and warty.

III. Food and Habits.—In the case of country children both may be known; if so, let them state what they may have observed, add what may be necessary. In the case of town children, however, the facts must be told. Pheasants feed on berries, seeds, roots, young shoots of plants, worms, and insects.

They roost in trees at no great distance from the ground. During the moulting season, however, they roost on the ground.

They are fond of woods with thick undergrowth, in which, when disturbed, they seek shelter, running whilst it is possible rather than taking flight. The male bird takes flight much more readily than the female. The nest of the pheasant is on the ground, and is a mere rude heap of leaves and grasses, in which eleven or twelve olive-brown eggs are laid.

IV. The Pheasant Season.—The teacher will be guided by the locality of his school whether this to be questioned out or told.

In England and Scotland pheasant-shooting legally begins on the 1st of October, and ends on the 3d of February. The flesh of the pheasant is considered a delicacy, and the birds are sold in the season at a very high price, as much as 7*s.* being given for a brace at some seasons of the year.

V. The Home of the Pheasant.—This must be told. The pheasant is not a native of this country, but was introduced here from the south-west of Asia. The particular district from which it was brought is supposed to have been the banks of the river *Phasis* in the ancient kingdom of Colchis, on the eastern shores of the Black Sea. The bird is still found in a wild state in the Caucasian province. The date of its introduction into Britain is not known, but was certainly before the close of the thirteenth century.

Lesson 75.—THE PARTRIDGE FAMILY.

First—The Partridge.

I. Structure.—Show picture, and compare with pheasant—smaller birds, and far less striking either from the elegance of their form or the brilliancy of their plumage. The bill is short, bent down to the tip, and naked at the base. The wings and tail are short; the tarsi as well as the toes naked, and the tarsi are not spurred.

The female is rather smaller than the male. The upper parts of both are of an ash-gray colour varied with brown and black; the male has a deep chestnut crescent-shaped spot on the breast.

II. Food and Habits.—To be told or questioned out as the knowledge and experience of the children may require. The partridge is seldom found far from cultivated ground; it feeds on grain and other seeds, insects, and their grubs, especially those of the ant.

The nest is usually on the ground among the brushwood and long grass, or in fields of clover or corn, and generally contains from fourteen to twenty eggs. Both parents show a strong attachment to their young and great courage in defending them from assailants; they will also have recourse to stratagem to draw off the attention of the enemy to their brood. Mr. Marwick relates the following instance of this habit:—"As I was hunting with a young pointer the dog ran on a brood of very small partridges; the old bird cried, fluttered, and ran tumbling along, just before the dog's nose till she had drawn him to a considerable distance, when she took wing and flew still further off, but not out of the field; on this the dog returned to me near the place where the young ones lay concealed in the grass, which the old bird no sooner perceived than she flew back again to us, settled just before the dog's nose again, and rolling and tumbling about, drew off his attention from her young, and thus preserved her brood a second time."

The flight of the partridge is strong and rapid for a short distance, but it is not able to sustain its flight for any length of time.

Until the end of autumn the parent birds and their broods keep together in a covey; late in the season several coveys unite and form what is called a *pack*.

In England there are two species of partridges, the common and the red-legged; the latter is distinguished from the former by being somewhat smaller, and having short spurs on the tarsi.

III. Partridge Season.—Partridge shooting commences on September 1st, and ends February 1st. Like pheasants the flesh of the partridge is considered a delicacy, and the birds sell for a high price, as much as 5*s.* being given for a brace.

Second—THE GROUSE.

I. The Black Grouse, or Black Cock:

1. *Structure.*—Show pictures of male and female birds. Children describe such general characters as can be observed. Supply what cannot be seen, and so work out the following facts.

The black grouse is a larger bird than the partridge, being about 2 feet long, having a short, broad bill, with compressed sides; the nostrils covered with short feathers; over the eyes a spot of red. The wings are rounded, and of moderate size.

The colour of the male deep black, with a white band on each wing; tail forked, each part curving outwards; the under feathers of the tail white.

The plumage of the female orange-brown above, speckled and barbed with black; wing-coverts tipped with white; breast chestnut-brown, barred with black; tail slightly forked, feathers of an orange colour, spotted with black.

2. *Food and Habits.*—To be told. The food of the black cock

consists of seeds and berries of mountain plants, shoots of heath, pine, fir, and beech trees, and insects.

During the months of autumn and winter the males associate in flocks, but separate in March or April.

They are found in the mountain districts of the north of England, and are abundant in those of Scotland. In the summer months they live principally on the ground, but in the winter they seek the trees, and will then approach the farm-yards and share in the food of the poultry.

The nest is composed of a few stalks arranged on the ground in marshy places, and concealed by a tuft of tall grass or a low bush. The female deposits from six to ten or fifteen eggs.

II. The Red Grouse, or Common Grouse.—This bird is smaller than the black grouse. Its plumage is of a chestnut-brown, with fine zigzag bars and dots of black.

The red grouse is peculiarly a British bird. It is found in Scotland, in the high moorland districts of England, and in Wales.

The food and habits of this bird are similar to those of the black cock.

Grouse shooting commences on the 12th of August and ends on the 1st of February.

LESSON 76.—GEESE AND DUCKS: MEMBERS OF A FAMILY OF WATER BIRDS.

I. Structure:

1. *Points in Common.*—Show pictures, and if possible the head and feet of the birds, and by a careful observation of these the children will discover the chief points of structure common to both. What cannot be observed to be told.

The body boat-shaped. Plumage dense, glossy, and waterproof; a layer of down next the skin. See lesson on FEATHERS.

The legs are placed considerably backward, and hence their gait on the ground is waddling. The three front toes are united by webs, thus they are fitted for swimming.

Explain the action of swimming. In order to make the stroke the foot is first drawn forward, when the toes close together, and the webs fold, so as to offer to the water the least possible resistance. When the back stroke is made the toes spread out, and the legs are placed in an oblique position, and strike the water by being pushed backward.

The bill is large, broad, and somewhat depressed; the tip is furnished with a hard, curved nail. Both mandibles are covered with a soft skin. Along the edges of each mandible there are a number of tooth-like processes; these serve as strainers to secure the food. The tongue is large, fleshy, sensitive, and furnished along its edges with a kind of fringe.

2. *Points of Difference.*—The duck smaller than the goose. Plumage of the male (drake) more beautiful than the female (duck). The goose a large, heavy bird. Plumage of the male (gander) very similar to that of the female (goose).

Food of duck worms, insects, and soft vegetable substances. These taken into the mouth with the mud or ooze, which is got rid of through the laminated processes of the bill and fringes of the tongue.

Food of goose grass and grain, as well as worms and aquatic insects.

Habits of the goose much more terrestrial than those of the duck.

II. Value as Articles of Food.—Ascertain what the children know on this point. Add what may be necessary.

Note especially that the duck is valuable not only on account of its flesh, but also for its eggs. See lesson on EGGS.

Geese are reared in large numbers in Lincolnshire and Norfolk for the London markets. Two broods are often obtained in one year. The young are fit for table in three months after leaving the shell. The quill-feathers of the goose are of great value. See lesson on FEATHERS.

Ducks are sold singly or by the pair, geese generally by weight at so much a pound.

C. Domestic Animals which are the Companions of Man.

LESSON 77.—THE CAT.

I. Introduction.—The cat is a home-loving creature, and a favourite with women perhaps more than with men. It is capable of evincing great affection for individuals. The writer had a cat in his home for more than twelve years. It was a very gentle creature, and so attached was it to its mistress that when she was away from home for any length of time it would evince sorrow by going to the bed-room door and mewing piteously. One summer, while the writer and his wife were away for the vacation, the cat went to the old spot, refused to eat, and at last died of—so the young people said—a broken heart.

II. Habits:

1. The cat is very fond of warmth, and delights to lie on the hearth-rug in front of the fire or in the sunshine, with its fore paws doubled under its body.

2. It can distinguish sounds with which it has associated pleasure or pain; thus the bark of a dog will make it run away, while the call of the cat's-meat man or the clatter of plates will bring it out of its resting-place. While true that some cats evince great affection for particular individuals, as a rule they are more attached to places than persons, and their memory of places is very great.

3. Cat language is very striking. A mew evinces want, a growl anger, and a purr pleasure.

4. It shows its pleasure by rubbing up against persons and places, and prowls round and round when expecting to be fed.

III. Food, and Adaptation of Structure to obtain it:

1. FOOD.—Cats feed on raw flesh. Are very fond of fish. When they can obtain them prefer mice and birds, for which they will watch patiently. When these seen the creature first crouches on the ground to take an aim, leaps upon the prey, which it seizes with its claws, and then tears it to pieces with its powerful teeth.

Like all the carnivorous animals, cats can abstain from food for a long period. A fine tom-cat was accidentally locked up in a cellar for six months. At the end of that time the cellar was opened, and the cat was found alive, but of course in a very emaciated condition. With careful treatment it recovered, and it was, we are told, very careful never again to stay away from home for any length of time.

2. ADAPTATION OF STRUCTURE:

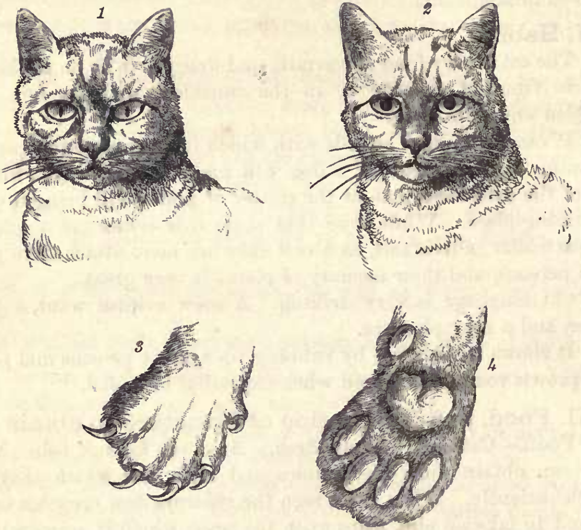
a. Senses: Sight.—Very acute. Iris opens and closes in a slit. The pupil can be much dilated, so that the creature can see with the smallest amount of light. *(Not true that cats can see in the dark.)* Both hearing and smell very keen.

b. Has special Organs of Touch.—On either side of the mouth a bare patch of skin, in which are placed a number of long, powerful hairs, the bulbs of which are furnished with blood-vessels and nerves, and so form so many organs of touch. Each hair is called a *vibrissa.*

c. Structure of the Feet.—The cat is a toe-walker, and has padded feet. There are seven pads on the fore paws and five on the hind.

They are placed on the end of those bones on which the animal rests in walking. Hence the step is noiseless.

There are five toes to the fore paws and four to the hind, all of which are armed with retractile claws. An elastic ligament passes from above the root of the claw down to the second bone of the toe. There is also a long tendon which passes over the extremity of the last joint of the toe, as over a pulley. When this is pulled backward it draws down the claw. When the animal is at rest each claw is drawn back into a sheath, which entirely conceals it, and is there held by the elastic ligament. When the creature wishes to seize its prey the contraction of the tendons brings down the claws with great force, cutting their way into the flesh, and are there held at the will of the animal. When no longer required the tendons relax,



1, 2, Cat's Head, showing pupils closed and open. 3, Foot, with claws unsheathed. 4, Foot, showing cushions or pads.

Skull of the Cat.

and the elastic ligaments at once pull back the claws into their sheaths.

d. Form of the Head.—The muzzle is short and round, and the jaws short and round, and worked by powerful muscles. The teeth are fitted for seizing and cutting. They consist of six small incisors in each jaw. These are followed by powerful canines, and these by four sharp molars on each side of each jaw. These are fitted for cutting, not chewing. The jaws have no lateral motion, and as the crowns of the molar teeth overlap each other the jaws act as a cutting machine.

e. Tongue covered with small horny points projecting backwards, and forming a kind of file, with which the animal can rasp off particles of flesh adhering to the bones.

LESSON 78.—THE DOG.

I. Habits.—Let the children say what they have observed as to the habits of the dog. Tell what may not be known, and so work out that the dog is attached to *persons* rather than places, and is the companion of man in all countries. It runs with its nose near the ground, and, when hot, with the tongue hanging out of its mouth, moisture often dropping from the tongue. It turns round repeatedly before lying down, and pricks up its ears at the least noise and barks. It seems to have an antipathy to cats. Obtains its prey by chase.

The dog is one of the most intelligent of animals, and can be trained to render great service to its master.

II. Structure.—To be worked out by observation of diagrams, by questioning on what may have been observed in the living animal, or telling.

1. *Body* somewhat longer than the cat's. Legs slender, but muscular. Chest wide and deep, so affording great lung power, and thus fitting the animal for the chase.

2. *Head* pointed. Jaws armed with powerful teeth similar in structure to those of the cat.

3. *Tongue* soft, and used to lap up its drink. As the dog never perspires, when the blood is heated the superfluous moisture is got rid of by the tongue, hence the habit of running with the tongue hanging out of the mouth.

4. *Feet* padded. The fore feet are furnished with five toes and the hind four. The two middle toes are longest and equal, the outer two shorter, the fifth on the fore foot never reaches the ground. Each

toe is armed with a strong, blunt, *non-retractile* claw. Hence the dog, though a toe-walker, has not the noiseless step of the cat. Claws more fitted for scratching or digging than holding.

The senses of *sight*, *hearing*, and *smelling* are very acute. It is chiefly by the exercise of the latter that it obtains its prey and traces its master.

5. The sense of *taste* not very fully developed, hence the dog will eat carrion flesh if none other can be found. Like all other carnivorous animals the dog can remain for a long period without food. An example of this is given in *Nature* for 1880, p. 347. A Skye terrier was left in a house by accident, its master locking the street door on his going away on a journey. He was absent for one month and five days, and on entering the house on his return he found the dog still alive, though thin and blind. During the whole of this time the dog had had neither food nor water.

III. Kinds.—Illustrate by pictures.

1. *The Greyhounds.*—Distinguished by having long and slender bodies, with round necks; head and muzzle lengthened, the latter terminating in a sharp nose.

a. The English greyhound is distinguished by its slender and elegant form, and lengthened head and muzzle, and sharp-pointed nose; the ears are small, and partially drooping. The body is clothed with fine smooth hair, fawn-coloured or black. This dog has little power of smell, and so is kept for the chase of the hare, which it pursues by sight.

b. The Scotch Deerhound.—This is a fine dog, standing 2½ feet in height at the shoulders. It is clothed with rough, coarse hair, and is exceedingly muscular and powerful. It is chiefly used for the chase of the red deer.

2. *Spaniels and Hounds.*—All pursue their prey by scent.

a. The Spaniels.—These dogs are clothed with long hair, more or less waved or curly, and have large pendent ears. The Newfoundland is a spaniel of large size, very muscular and powerful, and fond of water; hence its great usefulness in saving persons from drowning. Among the spaniels may be mentioned the water-spaniel, the setter, and King Charles spaniel.

b. The Hounds.—The hounds comprise the various kinds of dogs used in sporting, such as the beagle, and the harrier, used for hunting the hare; the fox-hound, and used only for fox-hunting; the stag-hound, a large stout animal, kept solely for hunting deer; and the blood-hound, the largest of all the hounds, and used to track men.

c. The Sheep-dog.—These dogs have the muzzle sharp, the ears short and erect, and are covered with a thick shaggy hair. The tail is slightly turned upwards, and long, and almost as bushy as that of the fox. The colour of the hair is black, or black mixed with gray or brown. These dogs are perhaps the most intelligent of their race, and among them the variety called the Scotch collie excels in its sagacity and in its fidelity and devotion to its master. The following instance of these qualities is given in the *Annals of Sporting*, vol. viii. p. 83:—"A shepherd in one of his excursions over the Grampian hills to collect his scattered flock took with him one of his children, about four years old. After traversing his pastures for a while, attended with his dog, he was compelled to ascend a summit at some distance. As the ascent was too great for the child, he left him at the bottom, with strict injunctions not to move from the place. As soon, however, as he reached the summit, a thick mist came on, and almost changed day into night. He returned to seek the child, but was unable to find him, and after a long and fruitless search returned to his cottage. His poor dog was also missing. On the next morning the shepherd renewed his search, but without success. He found, however, that during his absence the dog had been home, and on receiving his allowance of food instantly departed. For four days the shepherd continued his search with the same bad fortune, the dog as regularly coming for his meal and departing. Struck by this singular circumstance, the man determined to follow the dog. This he did. The animal led the way to a cataract at some distance from the spot where the child had been left. It was a rugged and almost perpendicular descent which the dog took, and he disappeared in a cave, the mouth of which was almost level with the torrent. The shepherd with difficulty followed, but on entering the cavern he saw his child eating the cake which the dog had just brought him, while the faithful animal stood by eyeing his young charge with the utmost complacency. The dog, by means of his scent, had traced him to the spot, and afterwards prevented him from starving by giving up a part, or perhaps the whole of his own daily allowance. He appears never to have quitted the child night or day except for food, as he was seen running at full speed to and from the cottage."

3. *Bull-dogs.*—These dogs have the head massive, the muzzle comparatively short, and the upper lip overhangs the lower. The principal varieties are the common bull-dog, the bull-terriers, the mastiffs, and the terriers.

The common mastiff is supposed to be peculiar to the British Islands. It is a dog of large size. Its head resembles the bull-dog, but its muzzle is larger, its ears larger and more pendent, and the upper lip more overhanging. It is chiefly used as a watch-dog, and in that capacity is both faithful and vigilant. It gets very much attached to those who own it.

The smooth-haired English terrier and the rough-haired Scotch terrier are noted for their courage and sagacity. They are all small dogs.

SECTION II.—COMMON PLANTS.

LESSON 79.—THE CABBAGE TRIBE.

I. Introduction.—Give the lesson in the spring of the year. Tell the subject several days beforehand, and encourage the children to notice any plants which they think belong to the tribe, so as to be ready with them when the subject is taken up. Take the children's answers. Supply what may be necessary, and so work out that the principal varieties of the cabbage family are—

1. *The White Cabbage,* with firm, compact, conical head, green externally, whitish within, and measuring from 3 to 15 inches in diameter, according to its age.

2. *The Red Cabbage,* of similar form to the white, but of a purple or red colour. Used for pickling.

3. *The Savoy,* with wrinkled leaves, either open or formed into a compact head. Furnishes a winter vegetable.

4. *Brussels Sprouts,* which in the early stages of their growth resemble the young savoy, but which afterward send up a long stem 4 or 5 feet high, from which, at the points where the original leaves join, sprout out small green heads, like small cabbages.

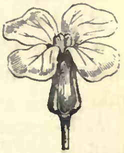
5. *The Curly Kale,* or, more properly, the *Borecole,* with open heads of curled or wrinkled leaves of a deep green colour. Some of the curlies have purplish or brownish leaves.

6. *The Cauliflower,* with the undeveloped flower-buds forming a close, firm cluster or head of a white colour.

7. *The Broccoli,* a variety of the cauliflower, but distinguished from it by flower-heads being of a purplish colour, and some kinds sending out sprouts when the flower-head has been cut off.

II. Members of the Cabbage Tribe.—Tell the children that there are several other common vegetables which belong to the same family of plants, and lead them to see why they are so grouped.

Show pictures of the flowers of cabbage, savoy, &c., and compare them with those of the turnip, radish, water-cress, &c. Enlarge the parts, and thus lead children to see that they all have four petals arranged in the form of a Maltese cross, and six stamens, two of which are shorter than the other four. The colour of the petals is either white or yellow. Such flowers are called *cruciform*, and the family of plants which have such flowers is called the *Cruciferæ*. It is an interesting fact that the order does not contain a single poisonous plant.



Cruciform Flower.

Tell children that the plants which they have mentioned belong to one division of the Cruciferæ, which furnish us with succulent vegetables. The other plants of the same division are:

1. THE TURNIP, which is cultivated for the sake of its root.

The turnip is a biennial plant, indigenous to Britain. In the first year it produces large roughish leaves, which spring directly from the root. As the season advances the upper part of the tap increases in size, and becomes of a globular form. In the second year a stem shoots up, crowned with numerous flowers, which give place to long thin pods containing a number of small seeds. As a garden vegetable the turnip is most useful, being very wholesome, and forming an agreeable change from the potato.

Though usually eaten boiled, turnips are perfectly wholesome in a raw state, and in that condition were formerly much consumed in Russia, even among the upper classes.

During the years 1629 and 1630, when there was a great dearth in England, very good and wholesome bread was made of boiled turnips, deprived of their moisture by pressure, and then kneaded with an equal quantity of wheaten flour, the whole forming what was called turnip-bread.

The earliest leaves, which are produced in the second year, form a very wholesome vegetable, and great quantities are sold in London and other towns under the name of *turnip-tops*. Raw turnips sliced and boiled with sugar are sometimes used as a remedy for hoarseness.

2. THE SWEDISH TURNIP.—The root of this plant is yellow, and grows to a much larger size than the white kinds. Though seldom used in this country otherwise than as fodder for cattle, the Swede is a very good vegetable for the table when boiled. The green tops are superior in flavour and delicacy to any variety of the cabbage. If earthed up in the spring they become blanched, and in that state furnish the best substitute for sea-kale.

The roots are said to be used in the manufacture of "orange" marmalade.

3. PUNGENT HERBS USED AS SALADS.

(1) *Water-cress.*

a. This plant is abundant in most parts of the country where there is running water, often forming extensive beds near the margin of brooks and shallow pools.

b. The stems are succulent and soft, with pinnated leaves. The leaflets are rounded, and that at the end larger than the rest. They are of a darkish-green or somewhat brown hue on the upper surface. The small white flowers open in July and August, and are succeeded by almost cylindrical pods spreading out from the stem.

c. It grows most luxuriantly in clear running water with a sandy or gravelly bottom. When grown in such a situation the plant becomes more succulent, and the leaves acquire a better flavour, than when springing from mud or stagnant water.

d. The peculiar flavour of the water-cress is due to the presence of a pungent oil which is present in every part of the plant.

e. The cultivation of this plant has now become a very important branch of market-gardening in the neighbourhood of all large towns, especially about London, and many thousands of bunches are sent daily to the several markets in the metropolis, where they are purchased by the water-cress girls and men, who hawk them about the town in the early morning and in the afternoon.

f. The anti-scorbutic properties of the water-cress make it a most valuable vegetable to those persons who are confined in workshops, factories, &c., and its free use is doubtless one mean of improving the health of the working-classes.

(2) *Garden-cress.*

a. This is a hardy annual plant, producing a number of small leaves. The flowering stem is branched, and rises to a height of about 1½ foot, producing small white flowers, which open in July or August.

b. It germinates very easily and rapidly, and is commonly used when the leaves are young and tender, either alone, or mixed with mustard leaves and other salad herbs.

c. The flavour of the cress is warm and pungent, hence it has received the name of *pepper-wort.*

(3) *Mustard.*

a. There are two species of mustard in common use, the white and the black. Both are annual plants, and found in great abundance in all parts of Britain.

b. The tender leaves of both are used as a salad, and the seeds of the black are ground into the mustard of commerce.

c. Mustard, like cress, germinates very easily. If the seeds are placed on a piece of flannel and kept moist they will soon grow, and in this way a wholesome salad can be obtained at all times of the year, even by those persons who do not possess a garden.

d. Mustard-seed ground into powder, besides being a wholesome condiment, is a most useful medicine. Mixed with warm water it forms the most ready domestic emetic, where, as in the case of vegetable poisoning, such a remedy is necessary before medical aid can be obtained. A paste made of the mustard-flour and spread on a piece of brown paper or linen rag forms an excellent plaster, which may be applied to the chest or other parts of the body as a remedy for internal inflammation.

The *radish* is another of the Cruciferæ, which is eaten as a salad.

Succulent Roots not belonging to the Cabbage Tribe.

LESSON 80.—THE CARROT AND THE PARSNIP.

Show flowers of these plants, and enlarge their parts, when the children will see that they differ from those of the cabbage tribe in several particulars.

1. Each individual flower has five petals and five stamens.

2. The principal flower-stalk gives rise to many smaller ones, each of which bears a flower; the whole are arranged like the ribs of an umbrella. Such an arrangement of flowers is called an *umbel*. When there is but one cluster it is spoken of as a *simple* umbel. When more than one, as in the hemlock, a *compound* umbel.

Umbels of the Hemlock Plant.

I. The Carrot:

1. *Character of the Plant.*—Procure a carrot with the leaves, and enlarge the picture of the umbel of flowers; children describe it.

(1) The root is a conical tap-root; the leaves are divided into many lobes, each of which is lance-shaped, all spring from the crown of the root; the stem which is thrown up in the second year attains the height of two feet, and is surmounted with tufts of

white flowers which open in June or July, and are succeeded by rough hairy grain-like seeds.

(2) Cut a carrot transversely, when the children will see that it consists of two parts of different colour and texture. *a.* The outer part —which corresponds to the bark of a tree—is darker than the inner and of a more pulpy consistence; and it is also sweeter to the taste. *b.* The inner part—which corresponds to the wood—is more fibrous, and is bristled over with hard points or fibres that extend to the rootlets outside.

Almost the whole crown of the root, the part which sends up the leaves, is connected with the wood. The outer part is more nutritious than the central part, and consequently the value of the carrot as an article of food will depend on the relative proportion of these two parts of the root.

2. *Value as Food:*

(1) Tell that the carrot contains a large amount of nutritious matter, chiefly starch and sugar, which together form about ninety-four parts in a hundred of the dried root, with a small quantity of a flesh-forming substance—albumen.

(2) Besides their use as human food, carrots are also grown for the consumption of horses and cattle. Cows, sheep, and pigs alike flourish on these roots.

(3) Other uses to which the plant has been put: *a.* In some parts of continental Europe a spirit is distilled from carrots, the abundant sugar of the roots being readily convertible into alcohol. It has been found that eighteen tons of carrots, the produce of one acre, will yield one hundred gallons of spirit. *b.* Sugar has also been obtained from carrots. *c.* In Germany a substitute for coffee has been made of carrots chopped up into small pieces and roasted. *d.* The boiled roots are sometimes used for poultices for application to ulcers and cancerous sores. *e.* The leaves were at one time used by ladies as ornaments for the hair. *f.* The leaf also forms a pretty setting for the bouquet or flower-stand; it is a good substitute for the fern leaf when it cannot be obtained.

(4) In order to preserve carrots for winter use, they are dug up in the beginning of November, and placed in a dry place in sand, by which means they may be kept without spoiling until March or April of the ensuing year.

II. The Parsnip:

1. Show picture or plant, and compare with carrot, when the children will see that it belongs to the same tribe as the carrot, and resembles it in its general characters.

2. The leaves are, however, larger, the parts not being so delicately formed.

3. The flowers are yellow, while those of the carrot are white.

4. The parsnip is a biennial and a native of Britain. It is usually sown at the latter end of February or March. The roots come to maturity at the latter end of October; this state is indicated by the decay of the leaf; they are then fit for use. Parsnips are not so susceptible to frost as carrots, and they may therefore remain throughout the winter in the ground without being injured.

5. In nutritive qualities the parsnip is inferior to some other vegetables, its most valuable constituents being sugar and mucilage.

6. Besides their use as a culinary vegetable, parsnips are applied to several other purposes. (*a*) In Ireland they were formerly fermented into a kind of beer, the roots being mashed up and boiled with hops. (*b*) Bread has frequently been made of them in time of scarcity, the powdered root being either employed alone or mixed with flour. (*c*) A wine may be formed of parsnip juice, and sugar has also been extracted from them.

7. The seeds are aromatic, and those of the wild plant were formerly collected and sold in the herb shops.

Lesson 81.—THE POTATO TRIBE.

I. Distinctive Character of the Plant.—Show picture of the plant as growing, and an enlarged diagram of the flower and seed-vessel, and let the children describe each, and so work out the following particulars:

1. The potato is an herbaceous plant, growing with a slender branching stem to the height of 2 or 3 feet.

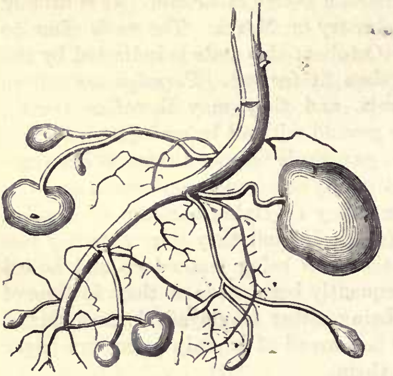
2. The leaves are simple, of a dark-green colour, of a roundish form, and of unequal size.

3. The flowers are of a peculiar shape when fully formed, the five sepals of the calyx double back upon the flower-stalk. The corolla is monopetalous, with five partings, and of a purplish tint or white. For general form of flower see night-shade.

4. The fruit is a large berry, with a greenish pulp, which changes to black as it ripens. In the centre there are numerous small seeds.

5. Besides the true roots, there are numerous runners which grow out of the stem, and which bear the potatoes, or tubers as they are called. The potato, therefore, not a root, but an underground stem.

Let the children examine a potato, when they will see that it has numerous scars or eyes. If the lesson is given in the spring they will see that from each of these scars a new plant is growing with rootlets, stem, and leaves.



Potato.

II. The Value of the Potato as an Article of Food.—Take the skin off a large potato, children will see that it contains a considerable quantity of water. Rasp the whole of the potato into a glass, and thus show that it contains two other substances — a pulpy material and starch. Give the proportions of each. In every 100 parts there are of water 72, starch 17, fibrous matter 9, other substances 2: total 100. Carefully wash the pulpy material until nothing but the starch remains. If this be rewashed and dried it can be used for all the purposes of arrowroot, sago, or tapioca. In the diseased potato the starch is in no way injured, and may be got out by rasping and washing.

III. Cultivation of the Potato.—*The usual Mode of cultivating Potatoes.*—This must be told to town children. Refer back to the fact that each eye on the tuber will produce a new plant. Children will thus see that if a whole potato be put into the ground it will produce as many new plants as there are eyes. But as each eye will produce a new plant the potato need not be planted whole, but cut into separate portions or sets, each piece of course possessing an eye.

Tell that this is what is really done. Some of the best tubers are chosen, and these cut into several large pieces, and when the surfaces of the cuts are dried they are planted in rows from 20 to 24 inches apart at intervals of 12 to 15 inches.

The proper season for planting the main crop is from the first week in April till the middle of May. In some parts of the country the farmers cut off both ends of the potato and plant the middle part entire.

When the young plants are about $\frac{1}{2}$ foot or 1 foot high some earth is drawn around the lower part of the stem; they are then left without any further care until the crop is matured. This state is indicated by the stalks beginning to decay, which usually takes place at the commencement or latter end of October. The roots are now carefully taken up with a fork, and the tubers stored away for winter use, care being taken to protect them from frost.

IV. The History of the Potato.—To be told.

The potato is not a native of the British Isles, but of America. It was introduced into this country by Sir Walter Raleigh in the year 1584 on his return from Virginia. It did not, however, come into general use for very many years afterwards. It was considered a great delicacy in the reign of James I., and at that period it formed one of the articles provided for the household of the queen. Its selling price was then 2*s.* a pound.

By degrees, however, its cultivation extended, first in Lancashire and Scotland, and afterwards in other parts of England, yet slowly in some parts. It was known in Yorkshire only as a garden produce down to 1760, and in Somersetshire it was rarely cultivated in the fields till after 1770.

The culture of the potato is now so extensive in this country that an abundant supply can be obtained in all places throughout the year, and such have been the improvements in the culture, and the varieties to which these improvements have led, that a succession is furnished fresh out of the earth for nearly six months of the year.

V. Other Plants of the Potato tribe:

1. *Capsicum.*—The fruits of this plant are commonly sold as *chillies.* Cayenne pepper is the powdered fruit of several species of the capsicum.

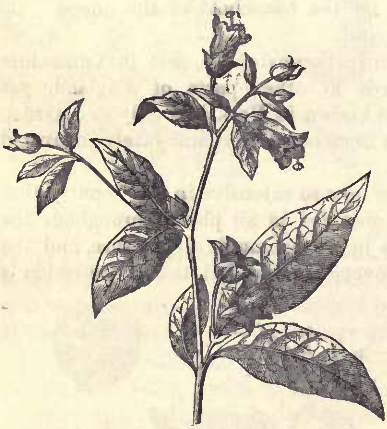
2. *The Love-apples or Tomatoes,* which are at the present time used in the preparation of sauces and as a vegetable.

3. *The Woody Nightshade, or Bitter Sweet.*—A common English wildflower found in almost every hedgerow. It is rendered conspicuous in summer by its bright purple flowers and

Woody Nightshade.

in autumn by its brilliant red berries. The flowers, which open all the summer, are in loose clusters, on short stalks opposite the leaves. They are of a bluish-purple tint, with yellow stamens, which project in a conical form around the pistil.

4. *The Black Nightshade.*—This is a common annual found on cultivated ground and by waysides. It grows from a few inches to a foot high, and bears small white flowers resembling those of the woody nightshade; they are succeeded by globular berries, green at first, but becoming black when ripe. Both the woody and black nightshades possess poisonous properties, and therefore children should be cautioned against eating them. Neither the woody nor the black are so dangerous as the *deadly nightshade,* a plant which was formerly reckoned as one of the same tribe as the potato, but is now classed with the henbane and the tobacco. It can be distinguished from the other nightshades by its flowers, which are of a dingy purple colour, solitary on short footstalks produced in the forks of the branches and the axils of the leaves. The flowers open in June, and are succeeded by green berries, which afterwards become red, and eventually black. These berries are among the most deadly of vegetable poisons. Children should be taught to distinguish them, and cautioned against eating them.



Deadly Nightshade.

LESSON 82.—PEAS AND BEANS.

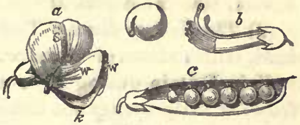
I. Structure of the Flower:

1. Draw diagram of the flower and seed-vessel of the pea and bean. Children describe their peculiar form. And first the *flower.* This consists of a calyx with five sepals; and a corolla of a very irregular shape formed of five distinct petals. The upper one is called the

standard, the two side ones the *wings*, and the remaining two at the bottom, which are united and inclose the stamens, form what is called the *keel.* The whole flower is butterfly-shaped (papilionaceous). The flowers are succeeded by long pods called *legumes,* consisting of two valves, to the upper one of which the seeds are attached in one row.

II. The Pea-plant:

1. Show picture, when children will see that the pea is a climbing plant, furnished with tendrils at the termination of the compound leaves. By these the plants intertwine with each other, or with some extraneous support.



Leguminosæ.

a, Flower of the pea. s, Standard. w, Wings. k, Keel. b, Stamina, nine connected, one free. c, Legume, seeds fixed to the upper suture in one row.

2. Question out or give the nature of the plant. An annual, going through all stages of its vegetation in a very brief period. Instances have been known of a crop being obtained from seeds matured the same season. Some Spanish dwarf peas were sown in February, and the crop was reaped the first week in July; some of the pods were left to mature their seeds, which, when sufficiently ripe, were again sown in the same piece of ground, and a second crop was reaped on the 27th of September.

III. The Kinds of Common Pea.—Show these; white or yellow and gray. The former are divided into garden and field peas, according as they are grown in the one or the other.

Of the garden peas there are many varieties, and they are generally classed as early or late sorts according to the time of the year when they produce their seeds.

IV. Uses.—As most of the uses will be known, they can be questioned out and classified.

In their immature state the soft seeds are cooked as a fresh vegetable. In their ripe state they are used in soups either whole or split. They are also made into puddings, and occasionally ground into meal.

V. The Bean:

NATURE OF THE PLANT.—Show picture of the flower and plant, and compare with pea. The bean has an upright fibrous stem, growing from 2 to 4 feet high. The flowers are white, with a black spot in the middle of the wing; these are succeeded by long thick legumes, woolly within, and inclosing large flat seeds.

1. KINDS:

(1) *The Windsor Bean.*—This is the largest of the bean tribe. It is said to have received its name from having been first cultivated in the neighbourhood of the town of Windsor by some Dutch gardeners, who came over at the Revolution in 1688.

(2) *The Kidney Bean.*—Two species of which are cultivated in England, both natives of warm countries, and though they grow and pod well in Britain during the warm months, they will neither bear the frosts of early spring nor those of late autumn.

The *dwarf kidney bean*, generally called the *French bean*, is a native of India; it has, however, been cultivated in this country for nearly 200 years. The *scarlet runner* was introduced from South America in the year 1633. The stalks of this plant will grow 8 or 10 feet high; they require tall sticks, round which they may twine.

2. USES:

(1) The immature pods of both the French bean and scarlet runner are used as a fresh vegetable, and the ripe seeds of the former are boiled as a vegetable under the name of haricots.

(2) Both peas and beans contain a substance called *legumine*, which is similar in its nature to the dried curd of cheese; but being rather difficult to digest is not fitted for those persons who have weak digestion.

Every 100 lbs. of dried peas contains 93 lbs. of nourishing matter, while 100 lbs. of wheaten bread contains but 80 lbs., and butcher's meat only 35 lbs.

Common Fruits.

LESSON 83.—THE APPLE.

I. Introduction:

1. Children to name the common fruits which are used in the present day, and with the teacher's help arrange them into four groups, namely, (*a*) those which grow wild in this country, and are not cultivated, as the blackberry and the bilberry; (*b*) those which, while found wild, are cultivated, as the strawberry, raspberry, plum, &c.; (*c*) those which are wholly cultivated, as the gooseberry and the currant; and (*d*) those which will not ripen in this country, as the orange, the lemon, and the grape.

2. Help the children to arrange these fruits into their proper groups, as (*a*) those which have a firm, hardish pulp, as the apple and pear—*pomes:* (*b*) those which have a soft pulp with a single stone in the middle, as the plum, cherry, &c.—*drupes:* (*c*) those which have

a soft pulp with small loose seeds, as the currant, the gooseberry, and the grape—*berries;* and (*d*) those which have a dry, hard covering with one seed, as the filbert, the Kentish cob, &c.—*nuts* or *glans.*

II. The Parts.—Distribute some apples among the class, and let the children point out and name the parts. What not known to be told:

The apple is joined to the tree by a stalk—the *peduncle;* opposite to the stalk is the remains of the flower cup—the *calyx;* the covering is called the *peel* or *rind.* Under the skin is the *flesh* or *pulp;* in the pulp there is *juice.*

Cut the apple in halves; in the centre of the flesh is the core, consisting of several cells—*carpels,* each of these contains one pip or seed.

III. Qualities.—Children describe the apple as a whole:—1. In shape something like a ball, but flattened at top and bottom—*globose.* 2. The stalk is short, brown, hard, and tough. 3. The remains of the calyx dry, shrivelled, and brown. 4. The rind is smooth, thin, tough, and coloured (according to specimen). 5. The pulp is white, rather hard, sweet, juicy, and has a pleasant odour and taste. 6. The core is stiff, tough, hard, translucent, and of a light yellowish colour. 7. The seeds are brown on the outside, and white within, oval, hard, and shiny.

IV. Uses:

Let the children name the different ways in which apples are used, correct what may be wrong, add what may be necessary, and so work out the following facts:

1. Ripe apples are eaten raw; both ripe and unripe are eaten when cooked; they are peeled before they are cooked.

2. Apples are made into tarts, puddings, and dumplings; they are sometimes stewed with sugar, and eaten with bread or boiled rice; they are also preserved in various ways.

3. The juice is made into cider. The apple is the fruit of the apple-tree; the place where the trees grow is called an *orchard.*

Additional information respecting the Apple for Elder Children.

1. BEST KINDS FOR THE TABLE.—Apples for the table should have firm juicy pulp, rich flavour, regular form or shape, and beautiful colouring. These qualities are found in the following varieties:—Sugarloaf pippin, autumn pearmain, king of the pippins; Ribstone pippin, Newtown pippin, nonpariel, and the russet.

2. BEST KINDS FOR THE KITCHEN.—Apples for cooking should be such as, when the pulp is heated, it becomes very soft; this quality is called "falling;" they should be large. These qualities are found

in the following varieties:—The codlins, the russets, and the Blenheim pippins.

3. Best Kinds for Cider.—Apples used for cider should have a rich juice, and this possessing some degree of astringency. Some apples which are too tough to be used either for the table or kitchen are found to be the best for cider; one of these is called the Siberian Harrey.

Cider is made by grinding down the pulp of ripe apples in a mill, collecting, and afterwards fermenting the juice. From 24 to 30 bushels of apples are required to make a hogshead. An acre of orchard will in a good season produce 600 bushels, or 20 to 25 hogsheads of cider.

The cider-making counties are Worcester, Hereford, Somerset, and Devon. The cider harvest is in September.

4. The Apple-tree:

(1) All the different kinds of apples have been produced from the crab, which is found wild in this country, and belongs to the rose family. The tree lives and bears fruit for a great many years; one known to have been sixty years old produced in one season 100 pecks.

(2) The wood of the tree is very hard, and fitted for the use of the turner; the wood of the crab is harder than that of the cultivated varieties.

(3) The bark contains a yellow colouring matter, which has been used as a dye for wool.

(4) The pulp of the fruit, boiled and dried in an oven, and mixed with two-thirds of its weight of flour, is said to form a wholesome bread. The fruit is cut and dried in America and Russia, and exported under the name of apple-rings.

(5) Of all the fruits grown in England the apple is the most serviceable; it is easily cultivated, remains longest in season, and when ripe can with care be kept until the new crop is on the tree.

(6) The other fruits of the apple family are the *pear*, the *quince*, and the *medlar*.

The Orange Tribe.

Lesson 84.—THE ORANGE.

I. Parts.—Compare the parts of an orange with those of an apple as to their nature.

1. The rind can be stripped off without breaking the pulp, because that part is covered with a thin skin.

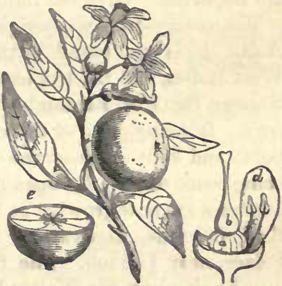
2. The pulp is not in one undivided piece, but is divided into eight (or ten) compartments, each of which is covered with a skin, and contains the pulp, the juice, and the seeds.

II. Qualities.—Children to describe the orange as a whole.

1. It is globose in form, soft to the touch, and has a pleasant odour.

2. The outside of rind is of a reddish-yellow colour and rough; the inside is white and smooth. It is tough and bitter.

3. Squeeze a piece of the rind in front of a lighted candle, when the children will see that the tubercles contain an inflammable juice. Tell that is a volatile oil. The tough rind protects the fruit, and so it can be kept for a very long time; the fruit can thus be enjoyed during a great part of the year.



The Orange.

a, The young seed-vessel. b, The pistil. c, Stamens. d, The petal. e, Section of the fruit.

4. Divide an orange into its separate compartments, and let the children describe them. Each has three sides, two of which are flat and rather broad, the other is curved, and wider in the middle than at the ends; the broad curved side comes next to the peel. The skin which covers the pulp is very thin, white, and rather tough.

5. The pulp is yellow, very soft, juicy, and sweet; it is very pleasant to the taste, cooling, refreshing, and wholesome.

III. Uses.—The children to give the uses as far as known, supply the rest, and so work out that the pulp of the orange is eaten raw as a fruit; the juice is sometimes made into wine (orange wine); the peel, when boiled in sugar, forms the candied peel which is put into plum-puddings and cakes. The pulp and peel of the Seville oranges are made into marmalade.

IV. The Tree.—From an examination of a picture children to describe the tree, the teacher supplying what cannot be observed, and thus work out that—

1. The orange is a middle-sized evergreen tree from 12 to 18 feet high, with a greenish-brown bark.

2. The leaves are oval (ovate); the leaf-stalk (*petiole*) is flattened (*winged*).

3. The flowers are white and formed in clusters on a common flower-stalk (*peduncle*); each flower has numerous (20) stamens.

4. In warm countries the tree flowers during nearly the whole summer, and the fruit takes two years to come to maturity, so that for a considerable part of each year a healthy tree has every stage of the production from the flower to the ripe fruit in perfection at the same time. One tree has been known to produce as many as 20,000 good oranges fit for packing, exclusive of damaged fruit.

V. The Countries in which the Orange-trees grow.—The children will know that the oranges which are sold in this country are imported. Give the following information respecting the tree:

The orange-tree was originally a native of the warmer parts of Asia. It is now found in the southern countries of Europe, in the West Indies, and the tropical parts of America. It will grow in the warmer parts of England—South Devon—but does not perfect its fruit. In many parts of this country the tree is grown in large square boxes and kept in conservatories during the greater part of the year, being removed to the open about the middle of June. Some very fine trees are now growing at Windsor Castle, Hampton Court Palace, Kew Gardens, Chatsworth Hall, Derbyshire, and in the Crystal Palace, near London. The first oranges were probably introduced into England by Sir Walter Raleigh, and it is stated that a relation of his planted their seeds, and they produced the orange-trees which at one time grew in a garden at Beddington in Surrey, and which are spoken of as flowering for more than a hundred years; they were destroyed by a great frost in 1739.

VI. Kinds and further Uses:

1. Show these if possible, and give names. The common or China orange, the blood-red or Malta orange, the St. Michael, the Seville, the Mandarin, the Tangerine, and the Bergamot.

2. The leaves of the tree yield a volatile oil called oil of orange leaf. The rind of the ripe fruit yields a fragrant oil called essential oil of sweet orange, that of the Seville, the oil of bitter orange. The rind of the Bergamot orange yields the essential oil called the oil or essence of bergamot, which is largely used in perfumery. The flowers yield the oil of Neroli; from this is distilled the orange-flower water of commerce. It is to the presence of the oil of Neroli that the odour of eau-de-Cologne is due. The flowers are also used for making marriage wreaths.

3. The wood of the orange tree is hard and compact, and is much used for inlaid work in fancy furniture.

LESSON 85.—LEMONS.

I. Differences between Lemons and Oranges.—Let the children compare the two fruits, and so work out points of resemblances and differences. Colour of lemon light yellow; shape oblong, with a nipple-like protuberance at the end. The juice of the pulp much more acid than that of the orange.

II. Uses.—Question out what known. Supply what may be necessary.

1. The juice contains a large quantity of citric acid, which is valuable as a medicine, and for making a cooling beverage—lemonade. Fresh lemon-juice is the best remedy for scurvy.

2. From the peel is distilled the essential oil of lemon, which is used as a flavouring agent in confectionery, in perfumery, and also in medicine.

3. The peel is also candied and used in confectionery.

III. The Tree:

1. One of the orange tribe. Grows to the height of 8 feet; has a rough bark; leaves of a pale green, and not winged; flowers resemble those of the orange.

2. The tree is a native of that part of India which is situated beyond the Ganges; but it has been introduced into the countries of Southern Europe—Italy, Sicily, Corsica, Spain, and Portugal.

3. The tree bears fruit twice a year; it flowers in May and in the autumn.

4. The fruit may be plucked and used at any time after it has attained a fair size, though it may be green. Those for exportation are plucked in September, while still green, and another crop early in winter.

In 1891, 5,178,676 bushels of oranges and lemons were imported into this country; the value of the whole was £1,591,052.

The other fruits of the orange tribe are the *lime*, the *citron*, and the *shaddock*.

Berries.

LESSON 86.—CURRANTS, GOOSEBERRIES, AND GRAPES.

I. Let the children compare these fruits as to their general resemblances:

1. General form similar, though they differ slightly in the par-

ticular shape. Globular, as the currants and some of the grapes. Ovate, as some of the gooseberries and some grapes.

2. The skin in all smooth, and the pulp very soft, watery, and luscious when ripe.

3. The seeds are small, hard, and imbedded in the pulp.

II. Differences.—By use of pictures, and questioning on what the children may have observed, work out the chief points of difference.

1. *In the mode of growth.*—Grapes and currants occur in bunches (*racemes*), gooseberries singly.

2. *In the nature of the plants* on which they grow. Grapes, the fruit of the vine, which is a slender plant needing support. Gooseberries and currants grow on bushes, the former distinguished by the presence of sharp spines on the branches.

3. *In the colour and kinds of the fruit:*

(1) Only three kinds of currants—red, white, and black. Gooseberries are either white, red, yellow, or green, and there are several sorts of each.

(2) There are four principal forms of grapes: (*a*) Round-shaped, which are either red, purple, or black. Some of the latter are grown in the open in England. (*b*) Oval-shaped, which are either dark red, or purple-black: the Black Muscadel and the claret grape are of this kind. (*c*) Round white, of which the Sweet-water is an example. (*d*) Oval white, of which the White, Hamburgh, and the White Muscats are examples.

4. *In the way in which the fruits are used:*

(1) Neither the currant nor the gooseberry is ever dried. They are either used fresh as a fruit or preserved as jam or bottled fruit.

(2) Grapes are used as a table fruit. They are never cooked in their fresh state. When dried they produce the so-called plums or raisins and currants sold by the grocer.

(3) The juice of all is used for making wine: gooseberries and currants for British wine. The grape for strong fermented wines, and sold as foreign wine, such as claret, hock, champagne, port, and sherry.

5. *In the way in which they are cultivated in England:*

(1) Gooseberries and currants are grown in the open, in orchards and gardens.

(2) The vine will not ripen its fruit in the open, so is grown in glass-houses called *vineries.*

One of the most celebrated vines in England is that at Hampton Court Palace. It covers a space of 1694 square feet, and seldom produces fewer than two thousand clusters of grapes every season.

In the year 1816 there were at least 2240, weighing each on an average one pound. So the whole crop weighed a ton. The vine still continues to produce enormous crops.

(3) Immense quantities of grapes are imported into this country from Spain, Portugal, the south of France, and other grape-producing countries of Europe.

Lesson 87.—STONE-FRUIT.

I. Points in which they resemble each other.—Show pictures or specimens of the common stone-fruit. Get names. *Plum*, *peach*, *cherry*. Compare with each other and with the berries, thus lead the children to see in what points they all agree, and how they differ from the berries.

1. They are all covered with a smooth skin which is difficult to separate from the pulp.

2. The pulp is more solid than that of the berry, and contains a seed which is covered with a hard case; hence called a *stone*. The kernel has a peculiar flavour.

3. They all grow singly, and as a rule on trees of considerable size.

II. Points in which they differ from each other.—To be worked out by comparison.

1. *Peaches and Nectarines* are larger than plums, and much more luscious.

The Peach.

The first is round, has a furrow on one side, and is covered with a delicate downy skin. The stone is large, rough, and in some kinds adheres to the flesh. The kernel has a peculiar flavour, which is due to the presence of prussic acid, a powerful poison. On this account it is dangerous to eat many. Peaches are eaten raw as a dessert fruit.

The fruit is produced upon the young wood of a year old. The blossoms come out before the leaves are fully expanded, and are of a delicate pink colour. The almond is the seed of one of the peach tribe.

2. *Plums* are of various sizes. They all have smooth skins, and

rather firm pulp. The stones are smaller than those of the peach and smoother.

3. *The principal sorts of the Plum which are in common use are:*

(1) *The Green Gage*, a roundish plum of very delicate flavour. Gage was the name of the family who first cultivated it in England.

(2) *The Orleans*, a large oval plum of various tints of red. This kind is named after that part of France which was held by England when it was first introduced into this country.

(3) *The Damson,* or *damascene* plum, so called because it was introduced from Damascus. The damson is one of the smallest of the plum tribe, and has a very astringent juice.

4. *Uses.*—Plums are eaten raw as a table fruit, and also when cooked in various ways. When ripe they are very wholesome; but as the skins are indigestible they ought not to be eaten, and it would be well to remove the stones of those which are used for pies and tarts. Dried plums form a large article of commerce under the name of *prunes* and *French plums.* The latter are larger and more saccharine than the former sorts, and are used as a table-fruit, while the former are more often stewed.

All sorts of plums produce their fruit on small natural spurs, rising at the ends, and along the sides of the bearing shoots, of one, two, or three years' growth.

The Cherry:

1. By comparing these with the others children will see that the cherry is one of the smallest of the stone-fruits, has a very smooth skin, and a small smooth stone.

2. The principal kinds are:

(1) *The Bigarreau.*—These are of a large size. Some are white, others black, and others of a pale yellowish red. They are considered the finest of all the cherries for table purposes.

(2) *The White Heart and Black Heart.*—These sorts are not quite so large as the Bigarreau, though resembling them in shape and quality. They are good table fruit.

(3) *The Kentish.*—These are of a medium size, round form, and of a light red colour. The stone is so firmly attached to the stalk that it may be pulled out of the flesh with it. This kind is one of the most valuable of the cooking or preserving cherries.

(4) *The Morello.*—These are large cherries of a heart-shaped form, and of a dark red colour. They are the most valuable kind for preserving purposes. They are used for making cherry-brandy.

It may interest the children to know that the cherry-tree is planted by the roadside in both Switzerland and Germany, and thus form beautiful avenues. One of these in Moravia extends the length of 60 miles, namely, from Brunn to Olmutz; and there are others of equal extent between Strasburg and Munich. These avenues are planted by the government, and all persons are allowed to help themselves to the fruit, the only conditions being that they do not mutilate the trees.

The mention of this fact will give the teacher the opportunity of condemning the bad practice of English boys and youths in damaging the trees by our roadside.

SECTION III.—COMMON MINERALS.

A. The Common Metals.

LESSON 88.—INTRODUCTORY LESSON.

Let the children name the common metals, iron, copper, lead, tin, and zinc. Show specimens of each in form of plate and wire, and work out, by methods suggested in lessons on the properties of bodies, in Part III. of this Manual, their distinctive qualities:

1. They are all heavy solids; much heavier than water. Arrange them in the order of their weight: Lead 11⅓ times heavier; copper 9 times; iron 7⅘ times; tin 7⅓ times; and zinc 7⅐ times.

2. Their polished surfaces reflect light in greater or less degree. Steel when polished is highly reflective. Tin is naturally a brilliant metal. Lead and zinc in an inferior degree, as they become dull when exposed to the air. *The brightness of the metals is called their lustre.*

3. They are all *fusible*, but melting at different degrees of temperature. The following is the order of their melting points from the lowest to the highest: Tin, lead, zinc, copper, cast iron, steel, wrought iron.

4. All are *malleable*, and in the following order from the greatest to the least: Copper, tin, lead, zinc, iron.

5. All are *ductile*, but not in the same degree. The following is the order of their ductility from the greatest to the least: Iron, copper, zinc, tin, lead.

6. All possess *tenacity*, but the degree is very varied. Steel is the most tenacious; supposing 42 to represent the amount of the quality, then iron will be 27; copper 3; zinc 2; tin 1¾, and lead 1.

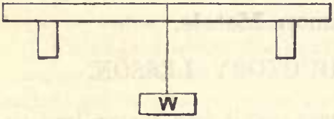
7. All are *conductors of heat.* The following is the order of their conducting power from the greatest to the least: Copper, zinc, iron, tin, lead.

LESSON 89.—IRON AND STEEL.

First—CAST AND WROUGHT IRON.

I. Qualities:

1. *Compare cast iron with wrought as to the distinctive qualities of each.* Cast iron brittle, and hence neither malleable nor ductile; wrought iron both malleable and ductile, and very tenacious. Good cast-iron is in some measure elastic, and capable of supporting a great weight without breaking. A bar one inch square when tested as in the accompanying diagram supported 20,500 lbs.; a bar of the best wrought iron of the same thickness supported 112,000 lbs. without breaking.



2. *Both cast and wrought iron rust when exposed to the action of damp air.* Water, however, when the air is excluded, has no effect on iron. Zinc in contact with iron retards the effect of damp air; hence the use of what is called galvanized iron, that is, iron coated with zinc; on the other hand, tin in contact with iron promotes the action, hence the importance of never leaving tinned sauce-pans wet after they have been used.

II. The Manufacture of Cast Iron:

1. ROASTING:

(1) Show the ore of the metal,—the common ironstone. Tell that in this case the metal is mixed with earthy substances, clay and sulphur, from which it must be separated.

If the children have had the lesson on SULPHUR they will be able to suggest a ready way of separating it from the ore, namely, by the application of gentle heat. Tell how this is done.

(2) The ore is broken into lumps about twice the size of the fist; these are mixed with small coal and built up into heaps, which are kindled and allowed to smoulder for a length of time. This process is called *roasting* or *calcining.* Sometimes the roasting takes place in kilns. During the process the ore loses about one-fourth its weight.

(3) The children will readily see that this process will only drive off the volatile portion, leaving the earthy matters behind; hence the necessity for some further operation, in this case the application of greater heat.

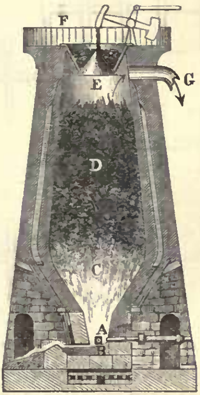
2. Smelting.—Show diagram of blast furnace, and explain the process. The furnace being heated with either coal or coke—

(1) *The roasted ore.*—From three to six cwts. of ore, according to its richness, is thrown on the top of the burning fuel, together with about one-third of its weight of limestone or quicklime, which is employed as a flux (Latin *fluo*, to flow), to bring the clay of the ore to a liquid state in the fire, in order that it may be separated from the iron. Upon this a charge of fuel is thrown, consisting of about 4 to 6 cwts. The heat of the furnace is kept up by means of a powerful blast of hot air, which is forced into it from large bellows worked by a steam-engine.

After an interval of half an hour or so, a fresh charge of ore, flux, and fuel is introduced, and the furnace is thus fed night and day for several years; indeed, until it may be necessary to cool it for the purpose of repair. (If the ore contains carbonate of lime, which it sometimes does, then clay is used as a flux.)

(2) As the iron is melted it runs down into the part of the furnace called the *crucible*, along with the liquid slag formed by the action of the lime on the clay.

The iron, which is the heavier, accumulates at the bottom, and above it five or six times its bulk of melted slag, which flows out of a place prepared for it in the side of the furnace, and is cast into blocks.



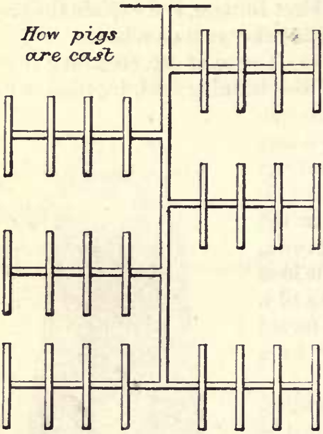
Section of Blast Furnace.

A, *The place where the blast of air is introduced.* B, *The hearth, built of very hard stone.* C, *The place where the heat is most intense, called the Boshes.* D, *The unconsumed fuel in the cone.* E, *A conical cover to furnace to keep in the gases, which are thus made to pass through pipe* G, *to be used as fuel to assist to heat the furnace.* F, *Gallery to enable men to feed the furnace.*

(3) At intervals of twelve hours the furnace is tapped by opening the top hole with an iron rod, and the liquid flows out into moulds prepared on the floor (see diagram on following page). The mass of iron which fills the mould is about 3 feet long and 4 inches in diameter, and weighs about 2½ cwts. Each separate mould is called a *pig*, and the iron cast in them *pig iron.*

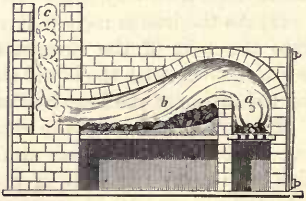
If the iron is intended for forge purposes, then moulds are made of iron. About five or six tons are run out at each tapping.

The iron thus produced is not all of the same quality. Some is gray, and some white; the former is considered the best. That which is intended to be formed into castings is melted in what is called a *cupola furnace*, and when in a fit state is run into the moulds prepared, according to the particular use for which it is intended.



III. The Conversion of Pig Iron into Wrought Iron.—Tell the children that the smelted iron took into itself a portion of the carbon of the fuel, and that it is this carbon which causes the iron to be brittle, and it must therefore be got rid of in order to render it malleable and ductile. This is effected by—

a. Refining.—The pigs are put into what is called a *reverberatory furnace* (Latin *reverbero*, to beat back). Illustrate the structure of this furnace, and thus lead the children to see how the metal is melted without coming in contact with the fuel, so that it cannot absorb any of the carbon, and what it does contain can be consumed by being formed into carbonic acid gas by union with the oxygen of the air. When melted it is stirred by a workman who uses a long iron rod. This operation is called *puddling*, and the man is called a *puddler*. After a certain amount of stirring the iron is collected into lumps called *blooms*. These are lifted out of the furnace, placed under a large hammer worked by steam-power, and beaten about one hundred times a minute. It is then rolled between steel rollers and formed into bars.



Section of Reverberatory Furnace.

a, The fireplace at one end. b, Flat bed or sole on which the iron rests. c, Chimney to carry off the gases.

By this process almost the whole of the impurities are removed, so that while the pig before it was puddled contained about 94 per cent of iron, when it is puddled it contains 99½ per cent.

b. Puddled bar iron is converted into the best bar by being again submitted to action of heat in the reverberatory furnace, and again beaten and rolled; this process is called *fagotting or piling*. It is now fully made wrought iron, possessing all those properties which render it so valuable, as malleability, ductility, tenacity, and the power of being welded together at a red heat; that is, two pieces can be united by hammering without the aid of a solder.

Wrought iron is the strongest of all metals, one of the most difficult to fuse, and the lightest and cheapest of all the common metals.

Second—STEEL.

I. Comparison of Steel with Wrought Iron.—Compare steel with wrought iron, both alike in being malleable, ductile, and tenacious, but the former possesses some important properties which the latter does not. It will receive a higher degree of polish, and can be hardened and tempered. (See lesson on a TABLE-KNIFE.) It can also be rendered permanently magnetic; hence its use for making the needles for the telegraphs. When tempered, possesses a high degree of elasticity, hence its use for watch and clock springs.

II. The Conversion of Bar Iron into Steel:

1. Explain the process of cementation. Bar iron placed in vessels filled with charcoal; these closed and heated gradually to a temperature sufficient to fuse copper. This heat continued for about four to ten days, according to the quality. It is then allowed to cool very gradually. About three weeks are occupied in the conversion of iron into steel: One to raise the furnace to the required temperature; one to keep it at the required heat; and one to cool it down.

2. When the bars are withdrawn they are found to have bubbles or blisters on their surfaces, whence they are called *blistered steel*.

3. Blistered steel is converted into *shear steel* by binding four or five bars together, raising them to a welding heat, submitting them to the process of hammering so as to weld the whole into one.

This kind of steel is used for making shears, scythes, knives, &c.

4. Blistered steel is converted into *cast steel* by breaking it into pieces, putting these into crucibles, and submitting them to a powerful heat. The melted metal is then poured into moulds.

BESSEMER STEEL.—This kind of steel is made out of *pig iron* by subjecting the melted metal to the action of air which is forced through it. The oxygen of the air unites with the carbon of the iron, forming carbon dioxide. The iron is thus brought into the state of puddled iron.

When the iron has thus been purified the requisite proportion of carbon to convert it into steel—about 10 or 12 parts to 1000—is given it by melting with it a certain quantity of white cast iron.

III. The Ores of Iron, and where found.—Show specimens; give names; point out localities, and so impart the following information:

1. Iron is found in great abundance in many parts of the British islands. It is always found as an ore, either as an oxide or a sulphide.

2. The two common forms of the oxide are the red hæmatite—red ore, and brown hæmatite or brown ore. These ores are very rich in iron—60 to 90 per cent. As they do not contain sulphur, they do not require to be roasted before smelting.

3. The common forms of the sulphides are the clay ironstones; these are always roasted before smelting.

4. The localities of the iron mines in England are Cornwall, Cumberland, Cheshire, Devonshire, Derbyshire, Gloucestershire, Leicesshire, Lancashire, Lincolnshire, Nottinghamshire, Oxfordshire, Staffordshire, Somersetshire, Warwickshire, Yorkshire, South Wales, Monmouthshire, and in the Isle of Man. Iron is also found in some parts of Ireland and in several parts of Scotland. The number of blast furnaces in action in 1890 were: England and Wales, 349; Scotland, 65. Total, 414.

IV. Statistics of the Iron Trade.—During the year 1890 the total quantity of iron ore produced was as follows:—From mines under the Coal-mines Act, 8,117,476 tons; from mines under the Metalliferous Mines Act, 2,648,267 tons; from open works, 3,015,024 tons; making a total of 13,780,767 tons, the value of which at the place of production was £3,926,445. In the same year 4,964,459 tons of ore were imported, making a total of 18,745,226 tons of ore smelted. The quantity of pig-iron produced from this ore was 7,904,214 tons, the value of which was £24,140,786. The quantity of coal used in smelting the ore was 16,766,694 tons. The average price of the best Staffordshire pig for the year 1890 was £3, 3*s.* 1*d.*; of the best Cumberland, £3, 18*s.* 8*d.*, and the best Cleveland, £2, 7*s.* 11*d.*, and of the best Scotch, £2, 9*s.*

The quantity of iron and steel, unwrought and wrought, exported from this country in 1890 was 4,001,430 tons, the declared value of which was £31,565,337. The value of the hardware and cutlery exported in the same year was £2,764,446.

LESSON 90.—COPPER.

I. Distinguishing Qualities:

1. By comparing it with the other common metals children will see that it is the only one which has a red colour. Tell that there is no other metal, except a very uncommon one called titanium, nor any metallic compounds, which have this colour.

2. By reference to the introductory lesson on the common metals show that copper is one of the most malleable and ductile, and after steel and iron the most tenacious, and after lead the heaviest.

3. If possible show three pieces of thin copper, one which has been kept in dry air, another which has been kept in a damp place, and a third on which some vinegar has been poured. Children to say what difference they observe in their condition. One is unchanged, one has a small portion of green rust on its surface, and the third has a larger amount of rust. Tell children that the green rust on the third piece is called *verdigris;* it is a very poisonous substance. The rust on the second piece is a *carbonate of copper*, which is also poisonous; hence the importance of cleaning and drying all copper sauce-pans after they have been used.

4. Make a piece of copper red hot, and let it cool, its surface will be covered with a number of black scales, which can be removed by bending the metal backwards and forwards. These scales are formed by the action of the oxygen of the air on the copper, and are therefore an oxide of copper.

5. Compare the piece which has been heated with one which has been hammered; the former is flexible and inelastic, the latter hard and elastic. Place the hardened piece on the end of a finger, and tap it with a pencil; it gives out a loud, ringing sound, hence said to be *sonorous*, or a loud sounding metal.

6. Place a small piece of copper in a strong solution of aquafortis (nitric acid), when it will be seen that it dissolves, forming a green-coloured solution. On account of nitric acid turning copper green it is used as a test for gold, it having no power over the latter metal.

7. Warm a piece of copper, let a child smell it, its odour is very disagreeable. It has also an unpleasant taste. Children should never put copper into their mouths, because it is poisonous, even in very small quantities.

8. Show a piece of polished copper. Children will see that its lustre is great. This is one of the reasons why it is made into tea-kettles, sauce-pans, &c.

II. Preparation of Metallic Copper from the Ore:

1. Kinds of Ore.—If possible show specimens of some of the principal kinds, and thus lead the children to see that it is found in several states.

(1) *In nearly a Pure State. This called Native Copper.*—The most remarkable masses of native copper hitherto discovered are those found in the mines of Lake Superior, some of which exceeded 150 tons in weight. In 1854 a mass of native copper weighing about 500 tons was found in Minnesota. Its division occupied forty men for twelve months.

(2) *Mixed with Sulphur and other Earthy Materials.*—These kinds are called *sulphides.* The most common are copper pyrites. This kind of ore contains about 34 per cent of copper, and is that which is mostly smelted in England. Another sulphide is called *copper glance,* which contains about 74 per cent of copper. It is found in Cornwall, where it occurs together with red iron ore.

(3) *Mixed with Oxygen.* These ores are called *Oxidized Copper Ores.*—The principal of these are: (*a*) Red copper ore, containing about 88 per cent of copper. It is found in large masses in the Burra-Burra mines, South Australia, and at Lake Superior. (*b*) Black oxide of copper, containing about 79 per cent of copper. It is found in large quantities at Copper Harbour, on Lake Superior, and at the Burra-Burra mines.

(4) *Mixed with Carbon and other Substances.*—The most common examples of this variety are: (1) the green malachite, containing about 57 per cent of copper. It is found in large masses in Russia, South America, and in South Australia. In the Russian court of the Great Exhibition of 1851 there was a suit of furniture exhibited which was made of polished malachite. (2) Blue malachite, containing about 55 per cent of copper. It is found in large quantities in Bohemia and in South Australia.

2. The Localities of the Copper Mines in this Country, and the Number of Mines in each District:

(1) *England.*—Cornwall 38, Devonshire 8, Lancashire 1.

(2) *Wales.*—Cardiganshire 3, Montgomeryshire 2, Carnarvonshire 3, Anglesea 3, Isle of Man—Great Laxey—1.

(3) Ireland 5.

(4) Scotland 1.

If the children have had the lesson on Coal they will know that the localities of the copper mines are far removed from the coal-fields, and will be able to determine that either the fuel must be taken to the metal mines, or the ore be taken to fuel districts. By reference to the relative bulk of a ton of copper ore with that of a ton of coal, metallic copper being nearly seven times heavier than Welsh coal (specific gravity of cast copper, 8·788; anthracite coal, 1·800), they will be able to determine which will be the more economical. Tell them that nearly the whole of the copper ore raised in this country is sent to Swansea in the Bristol Channel. The town is situated in the centre of a fine bay, has a harbour which is accessible in all weathers, and a productive coal-field immediately behind it.

3. THE PROCESSES OF REDUCING THE ORE.—The Common Sulphides.

(1) *First Operation.*—The ores, which have been previously broken into small pieces and sorted, are roasted or calcined to get rid of the sulphur and other volatile substances. The process is carried on in a reverberatory furnace (see "puddling furnace" in lesson on Iron). Each charge of ore weighs about three tons and a half, and is kept exposed to the action of the flames of the furnace for about 11½ hours. At the end of this time the calcined ore is raked out, and a new charge put in the furnace.

(2) *Second Operation.*—Melting the calcined ore in order to obtain the coarse metal. This process is carried on in a furnace similar in form to that in which the roasting takes place. The roasted ore is submitted to the action of great heat for about four or five hours, being well stirred during the time. During the process the metal sinks to the bottom of the furnace, the slag which is the lighter remains at the top. The tapping hole, which is in the side of the furnace, is now opened, and the melted metal allowed to flow into a pan placed in a pit of water; it thus becomes granulated. In this state it is called *coarse metal*, and consists of copper, iron, and sulphur, the copper being about 30 per cent of the whole.

(3) *Third Operation.*—The calcination of the coarse metal. The granulated metal is again placed in a furnace and submitted to the action of great heat for about 24 hours. By this means much of the iron is oxidised, and the sulphur driven off. The melted metal is again run into water, or cast into moulds. It is now very much purer, containing about 60 per cent of copper. In this state it goes by the name of *fine metal* when granulated, and *blue metal* when cast.

(4) *Fourth Operation.*—Roasting the blue metal. As the copper still contains about 40 per cent of impurities it is again roasted. For this purpose it is put into a furnace, and submitted to the action of the air at a high temperature for a period varying from twelve to twenty-four hours. At the end of this time the furnace is tapped, and the melted metal is run into sand moulds—pigs. The pigs are

covered with black blisters, in which state the copper is called *blistered copper.* In this state the copper is nearly free from all impurities, and is fit for the last operation.

(5) *Fifth Operation.*—Refining or toughening. To effect this the blistered copper is put into the refining furnace, and gradually melted. When reduced to a fluid state, the scum is skimmed off; the metal is next covered with charcoal; a pole, commonly of birch, is then held in the liquid metal. From time to time a sample is taken out of the furnace; and when it is found that the copper is quite malleable it is ladled out, and either granulated or cast into blocks called ingots, according to the use to which it is intended.

III. Statistics of the Copper Trade for 1890.—The total amount of copper ore raised in the United Kingdom during the year 1890 was 12,481 tons, value £32,471; amount of fine copper produced from this ore, 936 tons, value £57,650. Average price of tough ingot copper, £55, 3*s.* 10*d.* per ton.

In addition to the above, 613,619 tons of ore were imported into this country, producing 68,299 tons of copper, of the value of £90,612.

The exportation of unwrought and wrought copper in 1890 was 1,522,006 cwts., value £4,551,654.

Lesson 91.—TIN.

I. Qualities.—To be worked out by method suggested in previous lessons.

1. *Colour.*—Silvery white with a tinge of yellow, and possessing a high metallic lustre.

2. *Weight.*—Compared with lead it is a light metal, being only $7\frac{1}{3}$ times heavier than water.

3. *Malleability.*—Next to copper, tin is the most malleable of the common metals. It can be beaten out into sheets of $\frac{1}{1000}$ of an inch in thickness; in this form it is known as *tin-foil.* Tin is flexible when in rods, and emits in the act of bending a crackling sound, called the *creaking of tin.* As a small quantity of lead mixed with the metal deprives it of this quality, the crackling sound serves as a test of its purity.

4. *Ductility and Tenacity.*—At a temperature of 212° tin can be drawn out into a moderately thin wire, thinner than when the metal is cold; it has, however, a small amount of tenacity, not much more than lead, which is least tenacious of all the common metals.

5. *Fusibility.*—It is the most fusible of the common metals, melting

at a temperature of 442°; and if heated above this point in the air it burns with a brilliant white light. If the melted metal be exposed for any length of time to the action of the air the surface oxidizes; the scum thus formed, when taken off and reduced to powder, is sold under the name of putty powder, which is used to polish silver and other metals. Tin does not rust when exposed to either dry or damp air.

II. Uses.—To be questioned out, and what not known told.

1. As tin resists the action of air and water its chief use is as a covering for the surfaces of iron and copper to prevent them from rusting. When sheets of thin iron are covered with tin they are called *tin-plate;* they should, however, be spoken of as *tinned plate.*

It is common to speak of a tin sauce-pan, a tin kettle, &c.; but these articles are not made of tin rolled into plates, but of tinned plate.

2. *Tinfoil* is used instead of paper as a covering for fancy soaps, chocolate, and other substances of a similar nature, and also to keep moist substances from getting dry. It is also used in the manufacture of looking-glasses; without its help the quicksilver could not be made to adhere to the glass.

3. Tin is mixed with other metals to form alloys: mixed with lead in the proportion of three parts of tin to one of lead, it forms common pewter; mixed with an equal portion of lead, it forms pewter solder; mixed with a small quantity of copper and antimony, it forms Britannia metal; and with copper alone it forms bronze.

III. Where and in what state Tin is found.—Told.

1. Tin is found as an ore in the form of veins running through the granite and other rocks; in the sand and gravel of river courses, and on the slopes of the hills adjoining tin mines. The former kind is called *tin-stone,* and the latter *stream tin.*

The tin mines of England are confined entirely to the counties of Cornwall and Devon. The Latin name for tin is *stannum,* and so the districts in which the mines are situated are called the *Stannaries;* and as the Prince of Wales for the time being is paid a certain amount of money for the tin obtained from the mines, he is called "Lord Warden of the Stannaries."

2. Tin is found in Bohemia and Saxony in Europe; Malacca, Banca, and Billiton in Asia; and in Australia.

IV. The Reduction of the Metal from the Ore of Tinstone:

DRESSING THE ORE.—Necessity for each operation to be drawn out, and process illustrated as in previous lessons.

1. *Breaking and Sorting.*—When the ore is raised from the mine it is in masses of different sizes. The large lumps are broken in pieces about the size of a man's fist, those portions being put aside, which do not appear to contain sufficient ore to pay for the cost of dressing.

2. *Stamping.*—The ore thus broken and sorted is taken to the stamping-mill, and reduced to a rough powder.

3. *Washing.*—When the ore has been reduced to a powder it next undergoes a number of washings for the purpose of separating the coarser earthy particles from the metal.

4. *Roasting or Calcining.*—The washed ore is next dried, and then roasted in a reverberatory furnace to get rid of such impurities as can be removed by oxidization.

5. *Smelting.*—The roasted ore is now mixed with from one-fifth to one-eighth of its weight of small coal, and a little slaked lime. Occasionally, also, a small quantity of common salt is added. These materials are carefully blended, and damped with water. From 20 to 25 cwts. are now put into the smelting furnace (reverberatory) and gradually heated until the whole mass is fused. After about six hours the tin is found to be separated from the earthy portions, and sinks to the bottom of the furnace. The slag is now removed, and the tin ladled out and poured into cast-iron moulds.

6. *Refining.*—The tin obtained by the last process is still impure, and therefore it has to undergo the operation of refining in order to separate it from the iron and other metals with which it is mixed. The blocks are therefore put into another reverberatory furnace, submitted to the action of moderate heat, so that the tin may be melted without fusing the other metals. The tin thus obtained from the blocks is now subjected to a somewhat greater heat until it boils. Some green wood is next put into the molten mass, and after about three hours' boiling the tin is sufficiently pure for use. It is next poured into moulds made of granite, each of which holds about 3 cwts. The metal is now called *block-tin* or *refined tin.*

7. The block-tin thus formed produces what is called *grain-tin.* A block of tin is heated till it becomes brittle, when it is raised to a considerable height, and allowed to fall, whereby it is broken to pieces, which appear like elongated grains or tears massed together. In this state it is called *dropped* or *grain-tin.*

V. Statistics of the Tin Trade:

1. There were in 1890 eighty-one tin mines in England, seventy of which were in Cornwall.

2. The quantity of tin ores of all kinds raised during the year 1890 was 14,911 tons, the value of which in the market was £782,492.

The quantity of metallic tin obtained from the ore was 9602 tons, the value of which was £937,760. The average price of the best block-tin in the London market was £99, 12*s.* 0*d.* a ton.

3. During the same year 540,769 cwts. of block and other kinds of tin were imported into this country, the value of which was £2,797,274. The total exports of unworked tin in the same year were 102,642 cwts., the declared value of which was £503,371; and 421,797 tons of tinned plates, value £6,361,477.

LESSON 92.—LEAD.

I. Qualities.—To be worked out by methods suggested in previous lessons. The Latin name for lead is *plumbum*, hence the English word *plumber*, a worker in lead.

1. *Colour.*—A bluish-gray tint. *Lead gray* is an expression in common use to indicate kind of colour.

2. *Lustre.*—That of a freshly cut surface is bright, but it soon becomes dull from exposure to air. When once tarnished it does not alter its state by any further exposure to air or water.

3. *Hardness.*—Lead is the softest of the common metals. It may be easily cut with a knife, and may be scratched with the finger nail; it will make a gray streak on paper. It clogs an ordinary file, and can only be worked by a kind of file termed a rasp. It is very feebly elastic or sonorous, and gives out a dull sound when struck with a hard substance.

4. *Malleability and Ductility.*—Lead stands third among common metals in the order of malleability. It is also tough and flexible. It is the least ductile and tenacious of the common metals (see lesson on these properties).

When heated to a certain degree it may be squeezed out into solid or hollow cylinders. Solid cylinders or rods of lead are thus made for the manufacture of rifle bullets at the Royal Arsenal, Woolwich; and hollow cylinders or pipes are also largely made by the same process, instead of the old one of drawing out cold from short lengths cast hollow.

5. *Weight.*—Lead is the heaviest of all the common metals; its specific gravity is about 11⅓.

6. *Melting Point.*—Lead is very easily fused. It melts at a temperature considerably below that of red heat. Solid lead immediately sinks in molten lead of the same kind. When first melted it presents a bright glistening surface; but, if allowed to remain exposed to the

air, it soon becomes covered with a gray powder-dross. This rust is an oxide of lead, and is very poisonous, as are all substances in which lead is mixed, such as red-lead and white-lead, both of which preparations are used by painters in the preparation of their colours.

7. Lead is *tasteless*, but when rubbed between the fingers it emits a peculiar odour.

8. When two perfectly clean and level surfaces are pressed together they adhere with great *tenacity*. A leaden bullet cut through the centre with a sharp knife can be made into one again by pressing the halves together with a slight twisting motion.

II. Uses.—The uses of lead depend chiefly upon its fusibility, softness, flexibility, malleability, and its inelasticity. It is used in sheet form for covering the roofs of buildings, making gutters, and also for lining cisterns. It is cast into hollow cylinders and drawn out into pipes for water. Rolled out into very thin sheets, it is used for lining tea-chests, &c., and on account of its being readily fused and its weight it is made into bullets and small shot.

III. The Reduction of the Metal from the Ore:

1. The Kinds of Ore.—The ores of lead are of two kinds, those in which the metal is combined with sulphur, and those in which it is combined with oxygen; the former are called *sulphides* and the latter *oxides*. The most common example of the sulphides is galena, which is the principal source of lead. It is of a bluish-gray colour, possessing a brilliant lustre, which it always retains. It is very brittle, and breaks into cubes. This ore of lead mostly contains a certain amount of silver, from 5 to 10 oz. in a ton.

2. The Localities in which the Ore is found in this country, with the number of Mines in each place.

(1) *England.*—Cornwall, 5; Devonshire, 2; Somersetshire, 2; Derbyshire, 70; Cumberland, 25; Shropshire, 9; Yorkshire, 22; Westmoreland, 2; Durham and Northumberland, 38.

(2) *Wales.*—Cardiganshire, 33; Montgomeryshire, 12; Carnarvonshire, 15; Flintshire, 34; Denbighshire, 7; Carmarthenshire, 2; Pembrokeshire, 1; Isle of Man, 6.

(3) *Scotland.*—Lanarkshire, 1; Dumfriesshire, 2; Elgin, 1; Kirkcudbrightshire, 1.

(4) *Ireland.*—Clare, 1; Down, 1; Wicklow, 1.

3. The Preparation of the Ore for Smelting.

(1) *Sorting.*—When the ore is raised to the surface it is sorted out into three parcels called *knockings, riddlings,* and *fell,* the last-named being that which passes through an inch iron-wire sieve in

which the riddlings remain. The knockings are the larger pieces of spar or stone with ore intermixed.

(2) *Dressing.*—The sorted ore is next crushed in stamping-mills, and afterwards washed. These operations are repeated several times until all the earthy matters have been separated from the ore.

(3) *Roasting* to get rid of the sulphur. To accomplish this the dressed ore is put into a furnace, which is kept for some time at a moderate heat, so that about one-half the charge shall by the absorption of oxygen be converted into sulphate of lead.

When this has been effected the altered portion is mixed with the unaltered, and the temperature of the furnace raised. This causes all the impurities to pass off, the volatile portions as gas, and the solid portions rise to the surface in the form of slag.

(4) *The metallic lead* which is in the bottom of the furnace is now run off into a large iron pan, and afterwards ladled into cast-iron moulds. It then forms pig-lead.

(5) *The slag* or *scoria* contains a certain amount of lead, which is extracted in another furnace called a *slag-hearth*, and is also cast into pigs.

IV. Extraction of the Silver:

1. If the lead thus obtained contains a sufficient quantity of silver to render its separation profitable it can be obtained by a process called *cupellation*, which depends upon the property of lead to absorb oxygen from the air and become converted into an oxide, under circumstances in which silver undergoes no change, but retains its metallic form. The lead is fused in a furnace and exposed for many hours to the action of the air, by which means it becomes oxidized. As fast as the oxide is produced it is removed, and thus a fresh surface of the molten metal is exposed to the action of the air, and a further oxidation takes place, and so on until nearly the whole of the lead is removed and the silver remains, with but a small proportion of lead. This is afterwards got rid of by a further process of refining. The oxidized portion of the lead is again reduced to a metallic state by heating it in contact with coal.

2. In the present day the mode of obtaining the silver is generally the following, called Pattinson's Process, from the fact that it was first carried out by Mr. Hugh Lee Pattinson in the year 1833. The process is founded on the fact that in a mass of melted lead crystals of the metal are formed as the temperature sinks below the melting point, which crystals contain a smaller proportion of silver than the uncrystallized mass. The process is conducted in the following manner:—

(1) A number of iron pots, each capable of holding 5 tons of lead, are placed side by side over separate fires; one of the pots is filled with lead, melted, and skimmed of its impurities.

(2) The fire is then put out and the lead left to cool gradually. The crystals as they are formed are taken out in perforated ladles, which allow the uncrystallized portions to run through, and the crystals are transferred to the second pot, where they undergo a second melting and crystallization, and then to a third pot.

(3) The same thing is done a third time, and when no more crystals are formed the liquid is found to be very rich in silver. From this portion of the melted metal the silver is extracted by the process of cupellation.

V. Statistics of Lead.—In the year 1890, 45,651 tons of ore were raised in this country, producing 33,590 tons of lead, from which was obtained 291,724 ounces of silver; value, £58,040.

The average price of the best sheet-lead in the same year was £14, 13*s.* per ton.

The exports of lead—pig, rolled, and sheet—in 1880, were 55,557 tons; value, £812,330.

LESSON 93.—ZINC.

I. Qualities:

1. Show two pieces of zinc, one bright, the other dull. Children say what they notice as to their colour. Both are bluish-white.

2. Compare a piece of cast zinc with a piece of plate as to structure and hardness. The former is crystalline and brittle, the latter is malleable. Tell how the change was effected. When cast zinc is made a little hotter than boiling water it becomes malleable and does not lose the quality on cooling. It is not nearly as malleable as either lead or tin, neither is it so ductile or tenacious. (See introductory lesson on METALS for degree of these qualities and its weight.) By experiment lead children to see that it readily yields to the knife and clogs the file; it is, however, harder than tin.

3. Tell that it requires more heat to fuse it than either lead or tin, but less than copper. When brought to a bright red heat in a covered vessel it will boil and pass off in vapours. If the cover of the vessel be removed the melted zinc will burn with a bright bluish flame, and form an oxide of zinc.

4. Compare polished piece with dull. Tell that when zinc is exposed to damp air it rusts, but the thin coat of rust thus produced prevents the further oxidization of the metal.

II. Uses:

1. Elicit any which may be known, and the reasons why so used. Supply what may be necessary, and so work out that because of its lightness it is used for gutters, rain pipes, and covering for roofs of houses. Because it does not continue to rust with the action of damp air it is used as a covering to sheet iron and iron wire. Such zinc-covered iron is called *galvanized iron*. It is also made into saws for dividing blocks of salt.

2. Sheets of zinc perforated with holes are often made a substitute for wire-gauze for window-blinds, meat-safes, and other purposes.

III. In what state and where found.—Show the two principal kinds of ore.

1. The *sulphide* or *blend*, so called because of its shiny appearance. Miners call it *Black-jack*.

2. The *carbonate* or *calamine*, because it looks like a number of little reeds bound together, and the Latin word for reed is *calamus*.

Both kinds of ore are found in England, Wales, the Isle of Man, and in Scotland; but it is the sulphide that is most commonly obtained.

IV. The mode of obtaining the Metal from the Ore:

By reference to the constituents of the ore—sulphur, earth, and metal, the necessity for the various operations will be deduced, as also the nature of those operations. In this way work out the processes, telling what is necessary, and illustrating where possible to do so.

1. *Roasting the Ores to expel the Sulphur.*—This accomplished either in heaps or in reverberatory furnaces. The ore is crushed, mixed with fuel, and subjected to moderate heat for about twenty-four hours.

2. *Pounding the Calcined Ore.*—This is effected by putting the ore into a large mill constructed in a similar manner to our ordinary coffee-mills. After leaving the mill the pounded ore is sifted, and what will not pass through the sieve is again put into the mill.

3. *Mixing.*—The crushed ore is now mixed with about 45 per cent of non-baking coal (see lesson on FUEL) and some small coke. To this is added about 15 per cent of limestone, and about 5 per cent of common salt.

4. *Distillation of the Ore.*—The mixture is now put into large crucibles and placed in a cupola furnace. In the centre of the bottom of each pot is a hole closed with a wooden plug. When the ore begins to melt the pots are covered with a lid, and the heat of the furnace is increased. The part of the hearth upon which each pot stands is

perforated beneath, so that they can be reached from below. When, therefore, the fire has heated the pots and consumed the wooden plugs, one extremity of a long iron pipe is put into each hole, the other extremity dipping into a vessel of water. As the zinc is converted into vapour it passes down the pipe and is condensed in the water, forming a fine powder. This is called *raw zinc.*

5. *Refining.*—The zinc produced by the distillation is still impure, and has to be refined. This is effected by melting the raw zinc, but not raising the heat of the furnace sufficient to cause the metal to pass off in vapour. As the impurities rise to the surface they are skimmed off, and the pure metal is cast into ingots or bars. It is now fit for use.

V. Statistics of Zinc:

1. The ores of zinc are found in the following places:—*England:* Cornwall, Shropshire, Derbyshire, Cumberland, and Yorkshire—15 mines in all. *Wales:* Cardiganshire, Montgomeryshire, Denbighshire, Flintshire, Carnarvonshire, and Anglesea—33 mines in all. Isle of Man, at Great Laxey, 1 mine; Scotland, at East Black Craig and Queensbury, 3 mines.

2. The total quantity of zinc ore (principally black-jack) raised in this country during the year 1890 was 22,202 tons; value, £109,890. The metallic zinc obtained from this ore was 8582 tons; value, £203,358. The average price of good zinc in the same year was £23, 13*s.* 11*d.* per ton; and of sheet zinc, £22, 17*s.* 6*d.*

Lesson 94.—BRASS.

Notes.

I. Distinguishing Qualities:

1. Brass is distinguished from the other common metals by its yellow colour. It is not, however, a simple metal, but an alloy of copper and zinc, and consists of 2 parts by weight of the former to 1 of the latter.

2. It is harder than copper, and therefore better resists wear. It is malleable and ductile in a high degree; the former quality depends upon the proportion of copper. The so-called *Dutch metal* or *leaf,* which does not exceed $\frac{1}{52900}$th of an inch in thickness, is made by beating out a plate of brass.

3. Brass is more fusible than copper, and is capable of receiving

very delicate impressions from the mould, and so is well fitted for castings.

4. It is susceptible of a fine polish, and does not tarnish so soon as copper. By covering its polished surface with lacquer it may be kept bright for a very long time.

5. When made red hot and cooled gradually it is very tough, and can be formed into various shapes by hammering, becoming brittle, however, by the process. It can be again toughened by annealing. If raised to a very high temperature it also becomes brittle.

6. In the process of annealing the metal it becomes black. This blackness can be removed by plunging it into a solution of aqua-fortis and water (1 part of acid to 7 of water). The particular colour produced by dipping, as it is called, depends upon the proportion of the copper in the alloy. The greater the amount of copper the redder the colour, and the greater the amount of zinc the lighter the colour.

7. The bright surface thus produced may be preserved by coating the metal with varnish or lacquer. The best kind of lacquer for brass is made by dissolving shellac in spirits of wine and colouring it with dragon's blood, a resin obtained from various species of the calamus plants.

II. The Preparation of Brass.—The following is the method of making brass by the direct mixture of the two metals practised at Birmingham. The copper, which is first made red hot, is put into crucibles, and when this is melted the proper proportion of zinc is cautiously added, the mixture being stirred with an iron poker to ensure the union of the metals. As soon as the mixture is thoroughly effected the crucible is withdrawn, and the molten brass is cast either into moulds of sand or into iron ingot moulds, slightly warmed, oiled inside, and dusted over with charcoal powder.

If the brass is needed for castings then the ingots are broken up and melted, the metal in its fused state being run into the required moulds. If sheet brass is needed the ingots are rolled through steel rollers until of the required thickness. During the process of rolling the sheets are annealed from time to time in order to prevent the metal from becoming brittle.

Brass composed of 60 per cent of copper and 40 per cent of zinc is called Muntz's metal, and is extensively used for sheathing the bottoms of ships.

Lesson 95.—SILVER.

Notes.

I. Qualities:

1. *Colour.*—Silver, when in a compact mass, is remarkable for its whiteness. Tin most resembles it in colour, but that metal is not nearly so brilliant. In a state of extremely fine powder it is gray and earth-like.

2. *Lustre.*—Silver is capable of receiving a most brilliant polish. The best substance for polishing silver is that sold under the name of crocus or rouge.

3. *Hardness.*—Silver is harder than gold and softer than copper. It is scratched by copper. A bar of silver emits a dull sound when struck.

4. *Malleability and Ductility.*—In these qualities silver is only exceeded by gold. It can be hammered out into leaves $\frac{1}{10000}$th of an inch thick. A single grain may be drawn out into a wire 400 feet long. Thus 1 lb. troy of this metal could be drawn out into wire of this fineness, measuring 443⅓ miles long. It is hardened by hammering or rolling, but recovers its malleability by annealing at a low red heat.

5. *Tenacity.*—A wire $\frac{1}{10}$th of an inch in diameter will support a weight of about 240 lbs. without breaking. This is equivalent to about 13·64 tons per square inch.

6. *Melting Point.*—Silver is fusible at a bright-red heat, and when exposed to the air in the molten state does not undergo any further change, though it appears to have the property of *absorbing* oxygen, which it afterwards gives off during solidification. If placed between the carbon points of an electric lamp it quickly volatilizes, burning with a pale blue flame.

7. *Silver is not acted upon by the Atmosphere* at the ordinary temperature, but if exposed to air which contains sulphurous gases it soon tarnishes. It is this tendency to unite with sulphur that causes a silver spoon to tarnish when placed in the yolk of an egg. The property is made use of in the arts to produce the so-called "oxidized" silver ornaments which are sold in the present day. Such preparations should, however, be rather called "*brimstonized,*" as the peculiar dirty lead colour is not produced by the action of oxygen but by keeping the object immersed for some time in a hot solution of sulphide of potassium.

8. *Conductivity for Heat and Electricity.*—Silver has a higher

conductivity for heat and electricity than any other metal, and has therefore been adopted as the standard, and as equal to 100.

9. *Specific Gravity.*—Silver, when absolutely pure, is 10·53 times as heavy as water.

10. Silver is *tasteless* and *odourless.*

II. Alloys of Silver. SILVER AND COPPER:

1. These metals can be mixed together in any quantity. The colour of this alloy is white until the copper amounts to about 50 per cent, when it acquires a reddish tint; and beyond that proportion it becomes more and more red as the copper increases. Silver is made more elastic and harder by the addition of copper, and therefore more suitable for articles exposed to friction, such as money; and as a moderate quantity of copper (10 per cent) does not materially alter its colour, nor its capability of receiving a fine polish, it is always alloyed with that metal when used for coin or plate.

2. The proportion of silver in coin and plate is regulated by law. British silver coin must consist of 11 ozs. 2 dwts. of fine silver, and 18 dwts. of copper in the pound troy. This is termed sterling silver. In expressing the proportion of silver the word *standard* is commonly used. Thus sterling silver is said to be of the standard of 11 ozs. 2 dwts., the unit of weight being always the pound troy of 12 ozs. or 240 dwts. The 18 dwts. of copper in the pound is called its alloy. This particular standard for silver coins and plate was first defined by law in 1576. In 1695 the standard was raised to 11 ozs. 10 dwts. in order to prevent the conversion of coin into plate. In the year 1734 the old standard of 11 ozs. 2 dwts. was revived concurrently with the new, and these two standards still exist lawful, though only the former is in use.

The law requires that the quality of the metal of silver-plate shall be determined by trial—assay—at offices in various parts of the kingdom duly authorized for that purpose; and that if it be found equal to standard it shall be stamped at those offices with a series of marks which indicate the maker, the quality of the standard, the place of the assay, the year of the assay, and the payment of duty, 1*s.* 6*d.* per ounce.

III. The state in which Silver is found:

1. Silver is found both in a metallic state and as an ore. The former is called native silver, and is comparatively pure. Specimens have been found which contained 97 per cent of pure silver. Whatever impurities it has results from the presence of other metals, and not earths as is the case with the ores.

2. Native silver is found in the following places:—At Kongsberg, Norway—one specimen from this locality, now in the museum at

Copenhagen, weighs 500 lbs.; Saxony, Bohemia, the Hartz district of Northern Germany; Hungary and Spain. It is also found in Peru, Mexico, associated with native copper in the mines of Lake Superior, and in other parts of the world.

3. The principal ores of silver are—*silver-glance*, sulphuret of silver; *brittle silver ore*, sulphuret of silver and antimony; and *horn silver*, chloride of silver. These ores are found in the greatest abundance in Spain and South America.

IV. The Silver is obtained from the Ore by the following processes:

1. *Pounding.*—The ore is reduced to a powder by being ground in a mill and passed through a fine sieve.

2. *Mixing.*—The pounded ore is next mixed with from 10 to 12 per cent of common salt.

3. *Roasting.*— This process is carried on in a reverberatory furnace. About 5 cwts. of the mixture is laid on the hearth of the furnace and gradually brought to a dull red heat. It is kept in this state for several hours, being repeatedly stirred during the time. By this means some of the more volatile metals with which the silver is mixed pass off in vapour. The heat is now increased so as to decompose the salt, and thus form chlorides of whatever metals may remain.

The roasted mass is next ground to a very fine powder.

4. *Amalgamation.*—The pounded calcined ore is next put into casks, in which there are a number of iron balls and a quantity of water. The casks, which are about two-thirds full, are kept revolving for about two hours. When the pounded ore and water is thoroughly mixed, from 3 to 5 cwts. of mercury (quicksilver) are poured into each cask, and they are again kept revolving for 18 or 20 hours, by which time the mercury will have dissolved all the silver and any other metal which may be present.

As soon as the amalgamation is complete the casks are filled with water, and again kept revolving for two hours. By this means all the lighter portions of the mass are separated from the heavier metallic portions, which are then removed.

5. *Washing the Amalgam.*—The amalgam is next washed in clean water, first in vessels, and afterwards in canvas bags, any uncombined mercury which may be in the mass passes through the canvas, leaving the complete amalgam behind.

6. *Distillation of the Amalgam.*—The cleansed amalgam is next put into a still, which is gradually heated until the bottom of the vessel is of a dull red. The mercury now passes off in vapours, which

are caught at the end of the pipe and are condensed; the pure silver remains in the body of the still, and is now ready for the refiner, who extracts from it any impurities which it may contain.

V. Statistics:

1. The average price of standard silver for the year 1891 was $45\frac{1}{16}$*d.* per ounce. The quantity purchased by the master of the Mint for coinage was a little over 7,734,049 ozs.

2. The total silver coinage issued for circulation in the United Kingdom during the year 1891 was as follows:—

Coins.	Number of Pieces.	Weight—ozs.	
Crowns,	580,000	584,861	
Half-crowns,	1,984,000	1,016,488	
Florins,	20,000	$7,277\frac{3}{4}$	
Shillings,	3,629,000	1,168,540	
Sixpences,	5,112,000	805,949	
Threepences,	2,428,000	423,425	
Twopences,	4,752	144	Maunday Money.
Pence,	7,920	120	
Total,	13,765,672	$4,006,804\frac{3}{4}$	

3. In the same year 651,664 ozs. of worn silver coin were purchased for exchange for new; the loss by the exchange was £24,257, 15*s.* 9*d.*

4. The total silver coinage for the ten years ending December, 1891, was as follows:—

Coins.	Number of Pieces.	Weight—ozs.	
Half-crowns,	21,200,696	9,636,680	
Florins,	16,164,720	5,878,080	
Shillings,	48,407,040	8,801,280	
Sixpences,	49,737,600	4,521,600	
Threepences,	38,266,800	1,739,400	
Fourpences,	161,580	9,793	Maunday Money.
Twopences,	47,520	1,440	
Pence,	79,200	1,200	
Total,	174,065,156	30,589,473	

The total value of the coins thus issued was £8,412,105.

LESSON 96.—GOLD.

I. Qualities:

1. The only metal which in its pure state is *yellow.* Iron and copper pyrites are yellow, and are often mistaken for gold by the inexperienced. They can, however, readily be distinguished by the

hammer and knife. Iron pyrites cannot be cut, gold can. Copper pyrites when pounded affords a dull greenish powder. Gold cannot be crushed.

2. With the exception of platinum, the *heaviest* of all metals; it is nineteen times heavier than water.

3. The most *malleable* of all metals. It has been beaten out into leaves about $\frac{1}{282000}$ of an inch thick. A single grain can be beaten out to cover 56 square inches.

4. Its *ductility*, though not so great as iron, is very considerable. A grain of gold may be drawn out into a wire 500 feet in length.

5. Its *tenacity* is inferior to iron, copper, and silver, yet it is considerable. A wire $\frac{1}{36}$ of an inch in diameter will support a weight of 150 lbs.

6. With the exception of platinum and iron, gold is the most *infusible* of the metals. When fused it does not pass off in vapours, and so does not lose its weight, however long it is kept in a state of fusion. On this account it is sometimes called a *perfect metal*.

7. Gold has but little affinity for oxygen; it undergoes no change on exposure to the atmosphere, and is unaffected by any one of the strongest acids. It is, however, dissolved by a mixture of 1 part of nitric acid with 4 of hydrochloric; this mixture is called *aqua regia*.

II. The Alloys of Gold:

1. Copper and gold combine in all proportions without materially affecting the colour of the latter, except that it is somewhat redder. The density of the compound is less than that of gold, but the hardness is greater, and it is more fusible.

2. Jewellers alloy their gold with other metals for two purposes: first to reduce the value of the metal; and second, to produce special tints of colour. Thus red gold is obtained by combining 75 parts of fine gold with 25 of copper; green gold by combining 75 parts of fine gold with 25 of silver; dead leaf gold by combining 70 parts of fine gold with 30 of silver; and blue gold by combining 75 parts of fine gold with 25 of iron.

All these colours may be modified by mixing both copper and silver with the gold.

As a general rule the ductility of gold is much impaired by alloying other metals with it (especially so with iron), while its hardness is increased.

3. *Standard* is the term used to express the relation between the pure gold and the alloy in coins and articles of plate and jewelry. The degrees of the standard are expressed by the word *carat* (a term originally signifying the dried seeds of the locust-bean), of which, in

Germany, twenty-four were called a *mark*. Twenty-four carat gold is absolutely pure gold. At the present time five legal standards exist for gold ware, namely, 22, 18, 15, 12, and 9 carats.

The following are the composition and value per ounce of each, pure gold being at the present time worth £4, 4*s*. 11½*d*. per ounce:—

22 Carat.	dwt.	gr.
Fine gold,...	22	0
Fine silver,.	1	6
Copper,......	0	18
	24	0

Value, £3, 17*s*. 10½*d*.

18 Carat.	dwt	gr.
Fine gold,...	18	0
Fine silver,.	3	12
Copper,......	2	12
	24	0

Value, £3, 3*s*. 8½*d*.

15 Carat.	dwt.	gr.
Fine gold,...	15	0
Fine silver,.	5	0
Copper,......	4	0
	24	0

Value, £2, 13*s*. 1*d*.

12 Ct.	dwt.	gr.
Fine gold,.........	12	0
Fine silver,.......	7	0
Copper,...........	5	0
	24	0

Value, £2, 2*s*. 5¾*d*.

9 Ct.	dwt.	gr.
Fine gold,.........	9	0
Fine silver,.......	8	12
Copper,...........	6	12
	24	0

Value, £1, 11*s*. 10½*d*.

Articles of plate and jewelry made of these different values are "Hall marked" as explained in the lesson on SILVER. The duty paid for stamping *plate* is 17*s*. 6*d*. per ounce. Watch cases and articles of jewelry are exempt from this duty. Gold coins are made of 22 carat, which is considered the "standard" or "sterling" gold. The total gold coinage issued in 1891 was as follows: sovereigns, 6,179,706; half-sovereigns, 1,087,884; weight of metal, 1,826,739 ounces; total value, £6,723,496, 7*s*. 2*d*.

III. Occurrence and Distribution of Gold:

Gold is found in nature, chiefly in the metallic state, or as native gold, and less frequently in combination with lead, silver, and other metals.

The native gold occurs in cubes, and in the form of scales or spangles, and in rounded grains which, when large, are called nuggets.

Some very large nuggets have from time to time been discovered; one found in Ballarat in 1858, and called the "Welcome Nugget," weighed 2166 ozs., and its value was £8376, 10*s*. 10*d*. Another discovered in the Donally District, Australia, in 1869, weighed 2560 ounces, and its value was £9600.

Gold is found principally in quartz veins traversing slaty or crystalline rocks, and in alluvial deposits which are derived from the waste of the former.

The principal gold-producing countries at the present time are California, British Columbia, Mexico, Peru, Chili, Brazil, Bolivia, New Zealand, Queensland, Victoria, New South Wales, Japan, Russia, and the West Coast of Africa.

Gold is found in small quantities in some of the rivers of Europe, and also in some parts of Wales and Scotland.

The following are the quantities of gold obtained from each country in the year 1877, the last for which complete returns have been published:—

	Ozs.		Ozs.
United States,	2,050,000	Mexico,	65,950
Russia,	1,072,920	Bolivia,	64,310
Victoria,	963,760	Hungary,	61,214
New South Wales,	126,789	Brazil,	55,310
Queensland,	410,330	Japan,	21,660
New Zealand,	322,016	Chili,	12,860
Venezuela,	150,000	Nova Scotia,	12,039
New Granada,	112,500	Peru,	11,570
Africa,	110,100		

Making a total of 5,533,308 ounces, which, at the price of standard gold, would be worth over 21 millions sterling.

The total value of gold and silver obtained from all countries in 1891 was £39,591,218.

IV. The Extraction of Gold from the Sand or other alluvial Soil.—This is effected by washing, unless the scales are very small, in which case amalgamation is resorted to as in the case of silver.

When the metal occurs in connection with quartz rocks, then the gold-bearing quartz is first crushed in powerful mills, the pounded rock is next washed, the larger pieces of the precious metal being picked out, and the smaller portions obtained by amalgamation. The gold is obtained from the amalgam by the same process as in silver, which has already been described. The gold is then purified by the refiner, and either cast into ingots or granulated according to the purposes for which it is needed.

LESSON 97.—MERCURY OR QUICKSILVER.

I. Qualities.—A heavy metal, rather more than thirteen times heavier than water.

1. Mercury is the only metal that is fluid at the ordinary temperatures, becoming solid at 39° below freezing; it is then malleable.

2. It is of a silvery white colour with a striking metallic lustre. It does not tarnish when exposed to the atmosphere.

3. When pure it runs in small spherical drops over smooth surfaces; but when not pure the drops assume an elongated form, and leave a gray stain on the surface of the material. It boils at a temperature of 662° F. and forms a colourless vapour. This vapour can be condensed into a metallic state.

4. Like all other metals, mercury expands by heat, and its expansion is very regular from considerably below the freezing point to above 300°.

5. Mercury has a great tendency to unite with other metals without the addition of heat, thus forming what is called an *amalgam*.

6. Pure mercury is perfectly inodorous and tasteless.

II. Uses:

1. For filling the tubes of barometers and thermometers. Because of its weight, fluidity, and regular expansion and contraction by heat and cold.

2. For silvering looking-glasses. Because of its brilliancy.

3. For the purpose of extracting gold and silver from their ores.

4. In the manufacture of certain colours, as vermilion.

5. For medicinal purposes: calomel or blue pills and gray powder are preparations of mercury, as is also corrosive sublimate. All preparations of mercury are poisonous.

III. The State in which the Metal is found:

1. The mercury imported into this country is usually pure, but it is not found in any great quantity in that state, but as an ore called *cinnabar*, which is a sulphuret of mercury. This ore is very hard, has little or no metallic lustre, and is of a reddish-brown colour.

2. The principal cinnabar mines are those of:

a. Almaden in Spain. These mines have been worked for more than two thousand years. Pliny, the Roman historian, states that the Greeks obtained vermilion—a preparation of mercury—from them 700 years before our era.

b. Idria in Carniola (Austria). These mines were first discovered in 1497. More than 5000 cwts. is obtained from these mines yearly.

c. The Palatinate on the Rhine.

Mercury occurs also at Arqueros in Chili, at Huanca in Peru, at various places in Mexico, in Hungary, Sweden, at Shensi in China, Japan, and in Upper California.

IV. How the Metal is obtained from the Ore:

1. The ore is pounded.

2. The pounded ore is mixed with a certain portion of quicklime.

3. The mixture is placed in retorts, and heated until the mercury passes off in vapours.

4. The vapours are made to pass through cool troughs by which they are condensed. The metal is then put in vessels and exported.

B. The Common Earths, &c.

LESSON 98.—COMMON CLAY.

I. Qualities:

1. Provide two lumps of clay, one wet, the other dry. Tell that both were taken out of the earth, the dry piece some time ago, the wet one lately. Because clay is found in the earth, and is really a part of the earth, it is called an earthy mineral substance.

2. Let both pieces be examined, when children will discover that they are dull, opaque, and of a brown colour.

3. A child to scratch the dry clay with his finger nail. Call attention to what takes place; some of the clay comes off in the form of powder. Compare it with a piece of flint in this particular. Because clay will thus yield to the finger nail, it is said to be a soft mineral.

4. Next the child to rub the dry clay with his fingers, and say what he observes. It feels smooth, rather greasy, and the part which has been rubbed is shiny.

5. Place the dry piece on the child's tongue, ask what he perceives. It adheres to it. Dry clay always does this.

6. Drop some water on the dry clay; call attention to what has taken place. The clay has absorbed the water. Break the lump and place the pieces to a child's nose. What does he notice? The clay emits a peculiar odour; this called clayey.

Continue to drop water on the clay. The class will see that it has absorbed a large quantity. When it is quite wet roll a piece out, and form it into a cup, fill it with water. Call attention to the fact that none passes into the clay. Children will thus see that when once clay is saturated it is quite impervious to water. On this account it is used to line artificial ponds, lakes, canals, &c.

7. Mould the wet clay into various forms, thus showing that it is plastic, and by marking these with seals that the clay is impressible and inelastic. If the moulded forms are dried and baked the shape and impressions made on the articles will remain for any length of time. There are in the British Museum many tablets and vessels

which were made 4000 years ago and yet still retain their shape and inscriptions. Wet clay is moulded into bricks, flower-pots, tiles, drain-pipes, jugs, basins, and many other things.

8. Show some pieces of clay which have been made red hot. Children will see that they are red, very hard, brittle, and rough.

9. Pour water on these pieces of burnt clay. The class will see that they are absorbent. But the water runs through and does not soften the material. On this account it is used as a foundation for roads and paths. Burnt clay is bought and sold under the name of *ballast*.

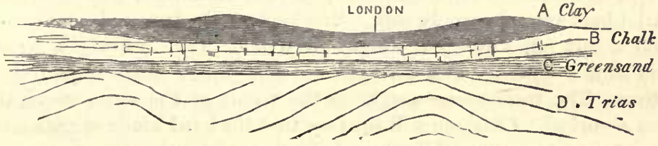
II. Kinds of Clay:

1. Show specimens, and thus children will see that all clay is not brown. That used in the kindergarten for modelling is white. This kind is called *pipe-clay*. Another kind, called *fuller's earth*, is of a greenish-brown colour. Fuller's earth is not plastic, so cannot be used for bricks or cups; but it has the property of absorbing oil and all kinds of grease, and it was at one time used for this purpose.

2. Some clays resist the greatest amount of heat that can be obtained, so that it is not possible to fuse them in a furnace. On this account they are called *fire clays*. Stourbridge clay and that found under the coal beds in Northumberland are among the best of this kind. Such clays are used for furnaces, bricks, and for pots in which to melt glass and refine metals.

III. How found:

1. Show diagram of London basin. Point out the layers of clay. Tell that such accumulations are called *beds*. They occur in different parts of England at various depths, and are of immense extent and considerable thickness, and frequently alternate with beds of gravel. In some places the clay is found at the surface of the ground, as is the case in most parts of London.



Section of the Thames Basin.

2. The quantity of clay used in this country every year is very great, as will be seen from the following returns gathered from the parliamentary papers for 1891:—

CLAY FOR MANUFACTURE OF PORCELAIN AND POTTERY.

Cornwall, ...	393,509	tons.
Devonshire, ...	60,346	,,
Dorsetshire, ...	50,000	,,
	503,855	,,
Fire Clays from all parts, ...	2,405,727	,,
Total, ...	2,909,582	,,

Total value of clays of all kinds produced in England in 1891, £899,166.

3. Clay contains a substance called *alumina,* from which the metal *aluminium* is obtained.

LESSON 99.—SLATE.

I. Qualities:

1. Provide several pieces of slate. Children give their colour. Darkish-gray. Such a colour is called after the substance a *slate* colour. But they are not all exactly of the same shade. One is bluish-gray, another is purplish-gray, another greenish, and another brownish. All are dull.

2. Direct attention to the structure of the slate. Made up of a number of layers. Break a piece; it splits into thinner layers, and these again into thinner. Very few minerals will divide in this manner; those that will do so are said to have a slaty structure and to have a laminated texture.

3. Let the children describe the slate by sense of touch. It is hard, but can be easily scratched, so is considered a soft mineral. All kinds are not equally soft. Previous to the lesson place a hard and a soft piece of equal weight in water. Take them out, wipe dry and compare. The soft piece is now much heavier than the other. The increase in weight is the result of the water which it has absorbed. Children will thus see that the hard kinds of slate are impervious to water, while the soft kinds are absorbent.

II. Uses.—Let the children give those they know, supply the rest, and so work out the following points:

1. Slate which is impervious to water is used to cover houses and lay between the bricks at the lower part of the walls, to prevent the water which is in the earth from rising through the bricks, which it always does if it is not prevented. Damp walls make a house unhealthy.

2. Although slate can be split into thin pieces it is not always so parted, but the large blocks are sawn into the required shape. When thus parted it is called *sawn slate*, and is used for many purposes, as large school slates, water cisterns, baths, chimney-pieces, shelves in dairies, and for paving stones.

III. Where found:

1. Slate is found in great abundance in Wales, where it forms the principal substance of the mountains. The chief Welsh quarries are at Bangor, Penrhyn, Festiniog, Llangollen, and Machynlleth. It is found in Killaloe, Valentia, and Benduff in Ireland; in some parts of Scotland; and in the English counties of Cumberland, Westmoreland, Lancashire, Devonshire, and Cornwall.

2. The largest slab of slate perhaps ever obtained was the one sent by the Llangollen Company to the International Exhibition of 1862. It was 20 feet long by 10 feet wide, and weighed 4½ tons. It was a very fine specimen of roofing slate, and could be divided into layers of $\frac{1}{16}$th of an inch thick.

3. The place from which slate is cut out is called a *quarry;* the men who hew it out are called *quarrymen;* the men who cut and split the slates are called *slaters,* and so are the men who fasten the slates on the roof of a house.

Lesson 100.—CHALK AND LIME.

First—Chalk.

I. Introduction.—This solid lump of white stone-like substance is called *chalk.* It was found in this state, so is a natural substance and a mineral. In the south of England some of the hills consist entirely of chalk. These hills are called the Downs. It is found under the surface in some parts of England, as, for instance, in London, under the clay.

II. Qualities.—By observation work out the following qualities:

1. Hard to the touch, but yielding to the knife, so regarded as a soft mineral; friable, when dry adhering to the tongue.

2. By experiment lead the children to discover that it can be softened with water, but not dissolved. When placed in a solution of acid and water it effervesces and alters the nature of the acid. It is this property which makes it useful as a remedy for vegetable poisons.

3. Show a piece which has been burnt, and compare with unburnt—former of a brownish-white colour, and much more easily crumbled.

III. Uses.—Elicit by questions those known, give the rest, and thus work out that chalk is used to write on slate, wood, and stone because friable. It is put on wet clayey soils because it makes them better fitted to grow certain kinds of crops. Finely powdered chalk mixed with water forms *whiting*, which is used as a polishing material for some kinds of metals, and also, when mixed with size and water, for whitewash. Burnt chalk is called *lime*.

Second—LIME.

I. Qualities:

1. To work out the qualities proceed in the following way: Tell that the substance on the plate is called *quicklime*. Put some in a saucer, sprinkle it with water, and let the children say what they observe. It has sucked it all up. Add a little more water; that is also absorbed. Pour more water on the lime and question thus: What do you see? Steam rising from the lime. Feel the bottom of the saucer. It is quite hot, and the lime is forming into a fine, dry, white powder. This powder is called *slaked lime*. The heat produced by the slaking of lime is sufficient to char and even kindle wood. Carts and ships conveying quicklime have been known to take fire by a shower of rain falling on it or by a leakage in the vessel.

2. Here is a bottle of water into which some slaked lime was put yesterday. Taste it. It is hard and acrid. This is caused by the small quantity of lime which the water has dissolved. Such water as this is called *lime water*.

3. Lime, either in its pure state as quicklime, or when slaked, has a peculiar effect on all animal substances. It is said to corrode them. If applied to the skin it acts as a caustic, that is, burns it. If a small portion gets into the eyes it causes inflammation, and even blindness.

4. Here is some spirits of salts. I will put some lime in, and touch your tongue with the mixture. All trace of the acid taste has gone. Indeed there is a new substance formed, which is different in its nature to either of the others. It is one of the curious properties of lime that it will unite with nearly all kinds of acids and form new substances. Mixed with carbonic acid it forms carbonate of lime, which is found in nature in the form of limestone and marble.

II. Uses.—Let the children give any of the uses known. Supply the rest, and thus work out that the uses of lime are numerous and important.

1. It is formed into mortar for building purposes. The lime being slaked is made into a soft paste with water. To this mixture sand is added in the proportion of about one part of lime to three of sand. As this mixture dries it becomes solid and durable. By absorbing the carbonic acid in the air it becomes a carbonate of lime. Examples are to be found of buildings a thousand years old, in which the mortar is as hard as the stones which it unites.

2. Lime is used in the manufacture of sugar, to deprive it of a portion of its acid.

3. Tanners use it to assist in removing the hairs from the hides, and to cleanse them from grease.

4. Lime-water and linseed-oil is a useful remedy for burns and scalds.

5. Lime is used as a manure to loosen soils which are too tenacious, and to render them more friable and capable of receiving the fibres of the roots of plants. It also helps to decompose the animal and vegetable substances of which mould is chiefly composed, and gives it the power of absorbing and retaining the moisture so necessary to the growth of vegetables.

III. How made.—Refer back to what is said about CHALK, and thus bring out that lime is not found as quicklime, but as chalk, or as limestone, and it is produced from these by means of burning. Explain how this is done.

1. The chalk or limestone, having been dug out of the earth, is taken to a low building called a *kiln.* A layer of chalk is covered with a layer of fuel, and on this another layer of chalk and another layer of fuel, and so on until the kiln is full.

2. The mass is then set on fire, and as the whole becomes red hot, the carbonic acid gas which is in the chalk is sent off, and the water turned into steam. When both these are driven off, pure or quick lime is left in the kiln.

It is very dangerous to remain in the neighbourhood of a limekiln, as the carbonic acid gas which escapes is poisonous. Cases have been known of persons lying down to rest near a kiln losing their lives.

Lime is sold by measure, either by the cubic yard or bushel. At the present time a bushel of the best kind is worth about 1*s.* 6*d.*, and the commonest sort about 9*d.*

LESSON 101.—BRIMSTONE OR SULPHUR.

I. Qualities.—Show a stick of brimstone; give its proper name, *Sulphur*. When sold in the form shown it is called *roll* or *stick sulphur*. Tell that it is a mineral substance. Children to be led by observation or experiment to discover its distinctive qualities. Thus work out that sulphur is of a bright yellow colour, tasteless, inodorous when cold, but slightly odorous when rubbed or made warm. It is heavier than water, and insoluble both in water and spirits of wine, but soluble in oil of turpentine.

Sulphur is very inflammable, burning with a dull blue flame, and emitting strong pungent fumes, which are very hurtful to health. Place a small piece into an iron spoon, and hold it over the flame of a candle so as to heat the sulphur without its touching the flame. It is easily fused, changing its colour from a yellow to a dark red. Pour the melted sulphur into water, when it will become solid, but soft and elastic. Tell that it will not remain elastic, but will again become brittle.

The following qualities to be worked out if the children are able to receive them:

1. Rub the bar with a piece of silk, and then hold it at a little distance from a few small dry feathers—down. Call attention to what takes place. The feathers are attracted by the sulphur. Tell why, and thus lead children to see that it is an electric. Tell that, though it will produce electricity, it will not allow that force to pass along, or through it, and so is called a non-conductor of electricity.

2. Put the roll on some heated substance, and allow a child to place one of his fingers on it. No heat passes through the sulphur, so it is also a non-conductor of heat.

II. Uses.—Let the children mention any uses to which sulphur is put, and the reason why so used. Supply what is not known.

1. Because sulphur will readily burn with a flame, it is used to cover the ends of the more common kinds of lucifer matches. For the same reason it forms one of the ingredients of gunpowder.

2. The fumes which rise from it while burning are used to bleach straw-plait, silk, and other substances.

3. Sometimes these fumes are used for the purpose of killing moths and other insects, and also to purify the air, furniture, and clothes in rooms where people have lived who had infectious diseases. When this is done great care must be taken not to let any person go

into the room while the sulphur is burning, as the fumes might suffocate them.

4. Because sulphur is easily fused, and becomes thin when made very hot, it is used in that state for taking casts of medals and coins. Melted sulphur is sometimes used as a cement to fasten iron bars into stone.

5. Large quantities of sulphur are used in the manufacture of sulphuric acid—oil of vitriol.

6. Show some flowers and milk of sulphur, which are sold by the chemist for medicine. Tell what they are. The former substance is composed of the vapours which rise from the sulphur when it is heated in a closed vessel. The vapours are caught in the top of the vessel, and as they cool they become solid. The latter substance is formed by boiling ordinary sulphur with slaked lime, muriatic acid, and water. The sulphur unites with the lime and acid, and is afterwards obtained in the form of a very fine powder.

III. Where found:

1. Tell that sulphur is found in the earth in the form of kidney-shaped lumps in connection with various rocks. It is dug out of the earth much in the same manner as coal or iron.

2. The chief sulphur mines are in Sicily, and from these mines more than 160,000 tons are obtained every year. In this state it is not pure.

It is also found in and around the craters of burning mountains. When found in this state it is called *native sulphur.*

3. Sulphur is also found mixed with iron and copper ores (see lessons on these metals). When these ores contain more sulphur than metal they are treated for the sake of the sulphur, either to produce stick sulphur or the sulphate of the metal. Such ores are called *pyrites* of the metal, and are spoken of as *sulphur ores.*

4. During the year 1890, 21,132 tons of such ore were raised from English mines, the value of the whole being £12,080; and 656,891 tons were imported, the value of which was £1,219,488.

LESSON 102.—MATCHES.

I. Introduction.—Let the children name the different kinds of matches they have seen, classify them, and so work out that those used in the present day are either wooden lucifer matches, or wax tapers called *vestas.*

Tell that the present lesson will be on the former kinds.

II. Kinds.—Have the various sorts examined, and so work out that the ordinary wooden matches are of two kinds: those which will light when rubbed against any dry surface, and those which will light only when rubbed on the side of the box prepared for them; the latter are called *safety matches.*

By experiment, or by questions on what the children may have observed, draw out that of these two classes there are several kinds, as:

1. Those which when rubbed light silently; and those which make a slight explosion.

2. Those which, when they ignite, give off pungent disagreeable fumes.

3. Those which do not give off such vapours.

III. The Parts of an ordinary Match. — Children to examine the matches and name the parts, viz. two, the wood, this is called the *splint;* and the material at one end which takes fire when struck, this is called the *igniting composition;* this is a chemical substance, and may be made of the following materials:—

Four units of weight of chlorate of potash; two units of weight of glue; one of whiting; four of finely powdered glass; one-half unit of weight of red phosphorus, and eleven units of water. To these are added some colouring matter according to the fancy of the manufacturer.

IV. The Manufacture:

1. *The Preparation of the Composition.*—If possible show the children the materials, or describe them, and thus lead class to see that these must be mixed; tell how done.

The glue and the potash are dissolved in hot water. The phosphorus is then added and carefully stirred until the whole is completely mixed. The solution is kept at a temperature of about 100°. The powdered glass and colouring matter are now added, and when properly mixed the composition is ready for use.

2. *The Preparation of the Splints:*

(1) *Cutting.*—The timber for match-making comes chiefly from Sweden and Canada, and is usually very straight-grained pine or aspen. It is sawn into blocks 12 feet long, 3 inches thick, and 11 inches wide. These pieces are again divided into blocks 5 inches long, the length of two matches.

By observing such a block and comparing it with a match children will see that it would be sufficient for a number of splints, so must be cut. Tell how this is done.

Blocks placed on cutting machine, and by means of a number of very fine blades or cutters divided into strips of the required thickness. Sometimes the splints are cut by means of a sharp knife, which is made to descend upon the block of wood in the same way that a pile of sheets of paper is cut by the guillotine knife, as it is called.

(2) *Drying.*—Tell that it has been found that the wood can be cut more easily when it is damp. It is therefore cut when somewhat green, or if old it is subjected to the action of steam for about twenty minutes. But as damp wood will not burn readily the splints are dried. This is effected by passing them through wire-gauze cylinders which revolve rapidly in a heated stove. When dried the splints are smoothed in a machine made for the purpose.

3. *Immersing in Paraffin.*—Let a child observe a lighted match and compare the manner in which it burns as compared with an ordinary splint of wood. He will see that the wood of the match burns more readily than the other does, and that there is a liquid oozing out. Tell that this is caused by a spirit oil called paraffin, in which the splint has been dipped after it was dried. This is effected by placing the splints in a bath of paraffin oil.

4. *The Dipping.*—By a consideration .of the exceedingly low price of a box of matches children may be led to conclude that the splints are not dipped separately into the igniting composition. Some other plan must be adopted. Tell how this is managed. The splints are placed side by side in a frame, which holds fifty or even more, the ends projecting beyond the edge of the frame.

When the machine is full the frame is taken to the dipper, who, if he is making common matches, dips the ends of the splints in melted sulphur, and when this has set, into the igniting composition. If the matches are of the better kind the splints are dipped at once into the composition, and then allowed to remain suspended a short time so that the composition may take a rounded form when it sets. The splints are now reversed and the other end dipped.

5. *Drying.*—When the composition is completely set the frames are removed to the drying room, where they are allowed to remain.

6. *Cutting and Packing.*—When dried the double matches are cut into two and put into boxes. When the boxes are filled they are placed in frames called *ducks*, which hold from three to four gross, and passed to the packing room, where they are put up into packages, glued up, and labelled.

SAFETY MATCHES.—Next call attention to those matches which will ignite only on the box, hence called *safety matches.* Explain why this is so.

The composition put on the match is made without phosphorus, and so will not of itself ignite easily by friction. The phosphorus in this case is mixed with powdered glass, glue, and water, and when properly mixed is painted on the side of the box, so that when the match is rubbed on that surface ignition is caused.

V. The Match Trade.—By considering the fact that in every household in this and other countries matches are constantly needed, and from the extreme cheapness of the article, children will conclude that the production of matches is so enormous that it is difficult to estimate it. Some idea, however, may be gained from the fact that it is reckoned that one large manufacturer in London turns out daily upwards of 80,000,000. In addition to the enormous numbers made in England, there is a large foreign trade in matches, chiefly with Sweden and Germany. Some of the foreign matches are sold at a marvellously low price. At the present time a neatly-made sliding box of matches and fusees combined in one piece can be bought for one farthing, as can also a similarly made box filled with wax tapers. One such box purchased by the writer contained forty tapers, and each burned for about fifty seconds.

It will interest the children to be told that although lucifer matches are now so common and cheap, they are quite a modern invention, being entirely unknown fifty years ago. Before that time all matches were made of thin pieces of wood, and their ends dipped in melted brimstone alone. When a light was required a tinder box was used. In this was kept some charred linen or calico, and on this some sparks were made to fall, the sparks being produced by striking a piece of flint on a piece of steel. When a spark fell on the tinder it made it red, and on this portion was placed the top of the match, the person aiding the ignition by gently blowing. Matches to ignite by friction were invented by a Mr. Walker of Stockton-on-Tees in 1829. In 1834 such matches were generally used, but they were sold at a much higher price than at the present time. The splints were first cut by machinery in 1842, when a Mr. Partridge took out a patent for a splint-cutting machine. In 1845 an Austrian, M. Schrotter, discovered how to prepare the red phosphorus now in use, and thus rendered the manufacture of matches harmless. This particular kind of phosphorus does not give off any fumes at the ordinary temperature of the atmosphere, and as the fumes of ordinary phosphorus are very detrimental to health, those who were employed in match-making before the discovery suffered greatly.

In 1855 Mr. Francis May took out a patent for the manufacture of his safety matches. From that time to the present the manufacture of these useful articles has been improved, and the result has been the production of both good and cheap matches.

LESSON 103.—GLASS.

I. Uses.—Children to mention the various uses to which glass is put, and under the teacher's direction classify them thus:—

1. For window panes, for which three kinds of glass are used: *crown*, *sheet*, and *plate*.

2. For wine-glasses, tumblers, decanters, and such like articles. These made of *flint* glass.

3. For the lenses of telescopes, microscopes, and other optical instruments. These are made of the finest kind of flint glass called *Strass* (from the name of its German inventor).

4. For smelling-bottles and ornaments. These are made of flint glass which is sometimes coloured in the making. Some coloured glass is used for the signal-lamps on railways and steam-vessels.

5. For wine, beer, and other bottles. These are all made of a coarse kind of glass called bottle glass.

II. Qualities which render it useful for these purposes.—Most of these can be drawn from the children, by reference to the object in view, in the particular use. Thus window panes needed to keep out wind and rain, and yet admit light; glass impervious to air and water, yet transparent, smooth, durable, does not rust, and can be easily cleaned.

The same qualities render it useful for lenses, &c. Its brilliancy and non-corrosive nature fits it for wine-glasses and other utensils for domestic use, ornaments, &c.

The only quality which mitigates against its usefulness is its brittleness, on which account it needs much care in handling.

Tell the fact that although glass is brittle in its solid state, when fused it is tough, ductile, and tenacious.

III. Substances of which Glass is composed.—Show these. Sand, some alkaline substances to serve as a flux or solvent, and in some cases a colouring matter. The following are the constituents of the various kinds:—

1. *Crown Glass.*—Sand, 5 measures; ground chalk, 2 measures; carbonate of soda, 1 measure; sulphuret of soda, 1 measure.

2. *Plate Glass.*—Fine Lynn sand, 400 lbs.; carbonate of soda, 250 lbs.; ground lime, 30 lbs.

3. *Flint Glass.*—Pure sand, 3 cwts.; carbonate of potash, 1 cwt.; red lead, 2 cwts.; saltpetre, $\frac{1}{4}$ cwt.; oxide of manganese, 4 to 12 oz.

4. *Common Bottle Glass.*—Sand, 100 measures; soap waste, 80 measures; gas lime, 80 measures; common clay, 5 measures; rock salt, 5 measures.

It will thus be seen that the base of all glass is *sand.*

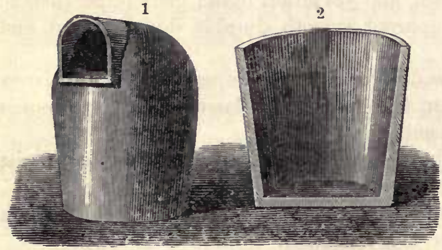
These materials mixed together are technically called *batch;* and when fused are termed *metal.*

If the flint glass is to be coloured, then to 6 cwts. of "batch" a certain quantity of some oxide of metal added according to the colour required. If transparent blue, then 2 lbs. of oxide of cobalt; if ruby, 4 oz. of oxide of gold; if purple, 20 lbs. of oxide of manganese; if emerald green, 12 lbs. of oxide of copper, and 12 lbs. of iron ore; if white enamel—opaque, 24 lbs. of arsenic and 6 lbs. of antimony.

IV. The Processes of Manufacture:

1. Mixing the Material.—The necessity for this operation can be deduced from the fact that alkaline substances being required as a flux to assist in fusing the sand, they must be mixed with it.

The sand is washed to remove all impurities, dried to get rid of the moisture, and sifted to separate it from all foreign substances, as cinders, &c. The dried sand is now mixed with the proper quantities of alkali and put into a barrel, which is made to revolve very slowly, until the various substances are entirely blended together.



Pots for making Glass.
1, *Covered Pot.* 2, *Section of Open Pot.*

2. Charging the Pots. — Show pictures of furnace and pots. Children will see that there are two kinds of pots—one open, the other with top; former used for crown and other common glass; the latter for flint and coloured glasses. The pots hold 18 cwts. The pots of glass are filled once a week on Friday or Saturday morning. The mixed materials are thrown into

the pots in quantities of about 4 cwts. at a time with iron shovels, allowing sufficient time between each filling for melting down the various charges until the pot is entirely filled with fused glass. By this method every pot in the furnace is fully charged with liquid metal in about 12 to 15 hours.

When the whole mass is fused the heat is continued for about 50 or 60 hours, by which time all the gas generated in the fusion, and all the air bubbles are driven off, and the mass has become homogeneous and ready to be formed into whatever article may be required; if window glass, either blown or cast; if a wine-glass or other vessel of similar form, then blown and shaped by hand.

3. EXAMPLES OF MAKING PARTICULAR KINDS OF GLASS:

(1.) *Crown Window Glass.*—The workman gathers about 10 lbs. of glass at the end of the blowing-rod.

Rolling this on the marver the workman makes the outer portion conical, and then by blowing forms it into a pear shape.

Further heating and blowing, in the intervals of which the gradually expanding bulb is rolled on a smooth iron bar, brings it into the shape of a flattened sphere.

The glass is now transferred from the blowing-tube to the pontil, on the end of which a little hot metal has been placed. The tube is now detached by means of a piece of iron dipped in cold water.

The globe of glass is now held by the pontil, and is carried by the workman to the nose-hole of the furnace, where it is heated. When quite soft it is taken to another furnace, called the *flashing furnace*, and kept constantly revolving by turning the pontil on a rest in front of the furnace opening. The revolutions are at first slow, but are gradually accelerated as the softening of the glass goes on, and the centrifugal force so produced throws the edges of the orifice outwards.

As the glass flattens it is revolved with greater rapidity, and at last it opens suddenly with a rushing noise like the unfurling of a flag in the wind caused by rapid flying outwards of the softened glass and the rush of the flames out of the mouth of the furnace. The mass of glass is now perfectly flat, and of equal thickness except at the centre where the pontil is fixed. It now forms what is called a *table* of glass, and when detached from the pontil is ready for annealing.

(2.) *Plate Glass.*—When the glass is perfectly fused the pot is lifted out of the furnace, wheeled to the casting table, and its contents poured upon an iron table of the size required, and the thickness is regulated by a strip of iron placed down each side of the table.

Immediately after it is poured out the melted glass is flattened by having a metal roller passed over the upper surface, which reduces the glass to the thickness of the strips at the side.

As soon as the glass is sufficiently cool to allow of its being moved, it is wheeled into the annealing oven, where it remains until quite cold, when it is polished.

(3) *Making a Drinking-glass.*—The process of manufacture is fully illustrated by the figures on opposite page.

a. A ball of molten glass gathered out of the pot with the blowing-iron, and rolled on the marver to expand it a little. Fig. 1.

b. The ball is then expanded to the required size by blowing through the hollow tube. Fig. 2.

c. A piece of molten glass is next fastened to the thick end of the bulb, and cut to the required size by the shears (Fig. 3). This is to form the stem.

d. The stem shaped by the use of the purcellas. Fig. 4.

e. Another lump of softened glass is next fastened to the stem so as to form the foot. Fig. 5.

f. The foot is now shaped as shown in Fig. 6, and finished as shown in Fig. 7.

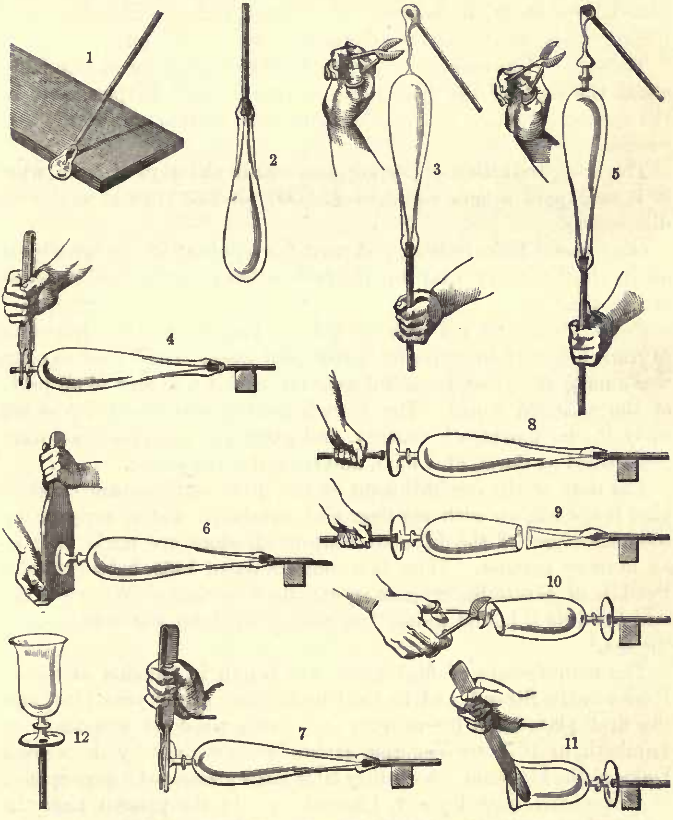
g. The workman now fixes the pontil to the under surface of the foot by means of a small piece of soft glass, as at Fig. 8. It is by this rod that the workman holds the object during the remainder of the operation.

h. The upper portion of the vessel is next separated from the lower, as shown in Fig. 9.

i. The vessel is now cut to the proper size with the shears, as shown in Fig. 10, and shaped as shown in Fig. 11. Figure 12 shows the finished article with the pontil affixed. The rod is removed by a sharp blow, and the article is ready for the annealing.

(4.) *Annealing.*—Tell the fact that when glass is allowed to cool rapidly it becomes very crystalline and brittle, in which state it would be unfit for use. To prevent this the article, whatever it may be, is made red hot, and in this state is passed into the annealing oven, which is so constructed that the newly-made object can be put in at one end, and gradually pushed out at the other, passing through in its passage the various degrees of heat from the red to that of the atmosphere. The time occupied in this process depends on the size of the article, from 6 hours in the case of a wine-glass to 60 for a large plate.

V. Historical Notices of Glass.—The oldest known specimens of glass are the coloured beads and other small ornaments found in the tombs of ancient Egypt. Some of these must have been made nearly 2000 years before the Christian era. One specimen—an urn—is stamped with the name of the queen Hatasu, who reigned about 1445 B.C.



Figures illustrating how a Drinking-glass is made.

Under the native Pharaohs glass seems to have been extensively exported to Greece and Italy, and for many centuries the Egyptians continued to excel in its manufacture. After the Egyptians the people of antiquity most renowned for glass were the Phœnicians, who are often spoken of as the inventors, but of this there is no direct proof. It is certain, however, that at one period of their history they produced some beautiful specimens of the art, and the glass vessels found in the ruins of Nineveh, one of which bears the name of Sargon, 722 B.C., were probably made at Sidon.

The art of glass-making appears to have been introduced into Italy about the date of the foundation of the Roman Empire, and in the course of years the manufacture was carried on with great success.

The first production of crystal glass was in the days of Nero, who, it is said, paid a sum equal to £50,000 for two cups of moderate dimensions.

Glass seems to have been first used for windows in the latter part of the third century A.D.; but the first authentic account of such use is A.D. 422.

From Rome the art was carried to Venice, and the island of Murano became famous for its mirrors and vases. The Venetian glass was among the most beautiful ever made, and was sent to all parts of the civilized world. The French government fostered the art early in the fourteenth century, and extensive manufactories were established at Paris, St. Cloud, and several other places.

The date of the establishment of the glass manufacture in England is not known with any degree of certainty. Yet as early as the commencement of the fifteenth century allusions are made to it in an indirect manner. Thus, in a contract dated 1439, between John Pruddle of Westminster, glazier, and the Countess of Warwick, the said Pruddle is bound to use "no glass of England, but glass beyond the sea."

The manufacture of flint glass was begun in London at Savoy House in the Strand, and in Crutched Friars in the year 1557, and the first plate glass for mirrors and coach windows was made at Lambeth in 1673 by Venetian artists brought over by the second Duke of Buckingham. A century later large glass-works were opened at Ravenhead, near Prescot, Lancashire. At the present time the principal glass-works are at Newcastle-on-Tyne, St. Helen's, Warrington, and Birmingham.

In Scotland the manufacture of glass was introduced in the reign of James VI., and one George Hay obtained a patent for thirty-one years. The first glass was manufactured at Wemyss in Fifeshire and afterwards at Prestonpans and Leith.

C. Fuels.

LESSON 104.—COAL.

I. Introduction.—Children to name the various substances used for fuel. Coal, coke, wood, charcoal, and peat. Show specimens of each. The present lesson and several others will be on coal. Question as to where and in what state coal is found. Hence it is a natural mineral substance.

II. Qualities.—Provide a large lump of common coal. Direct the children's observation so as to lead them to discover its qualities. It is *black*, has a *resinous lustre*, blackens the fingers when touched. It is *heavy*, *hard*, and *brittle*, breaking with a slaty fracture. It is inflammable. If there is a fire in the room put a lump of coal on and let the class describe exactly what takes place. At first some smoke comes out of the coal, then—if caking coal—some of the coal oozes out and bursts into a flame. Afterwards the whole lump blazes. After a time the entire lump gets red hot and burns away, leaving some ashes in the bottom of the grate. While the coal is burning it gives out heat.

III. Uses:

1. Let the children state the uses to which coal is applied, supply what not known, and so work out that the heat which comes from burning coals is used to warm the air in our dwellings, to cook our food, to dry wet clothes, &c., to make steam in the boilers of engines, to bake pottery, and smelt metals.

2. Coal is also used to obtain *gas*. Illustrate the process. Place some very small coal in the bowl of a tobacco-pipe. Cover the top of the bowl with a piece of damp clay, and place it in the fire. Children to observe and describe what takes place. After a short time some very light-coloured smoke comes out at the end of the pipe. Put a lighted match to this smoke. It burns with a bright flame. What is burning is the gas which has come out of the coal. When the gas has burnt out remove the pipe, cool the bowl, take off the covering, and show what is left, cinder or coke.

Tell that all the gas used in our towns is made from coal, which is heated in large closed vessels called *retorts*, which are placed in large fires. Show picture of a gas-house, and trace the process with more or less fulness according to the age of the children:

(1) Coal placed in the retort, door well secured, and heat applied.

(2) As the coal becomes heated the gas is driven off and passes along the pipe which is attached to the top of the retort.

(3) When all the gaseous portions are driven off the cinder in the retort is removed and sold under the name of gas coke.

(4) The gas which is driven off is very hot, and contains many substances which, if not removed, would unfit it for use. They are therefore got rid of in the following way:

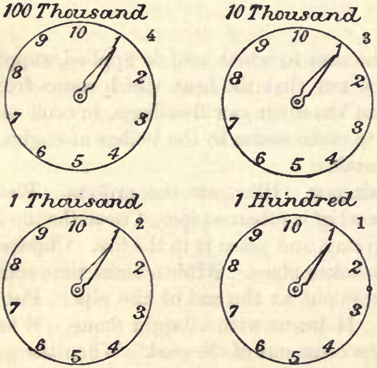
a. The heated gas is cooled in condensers, and the portions which will condense are deposited, forming what is called *coal tar* or *gas tar.*

b. The gas is still unfit for use, and so it passes on to the purifiers. In these all the impurities are removed.

c. The pure gas is now allowed to pass into large receivers called gasometers, where it is kept until wanted for use.

d. From the gasometers it is forced through large pipes called mains laid underground along the principal roads. To these mains are connected smaller pipes, which are laid along the streets, and to these are fixed smaller pipes, which convey the gas to the meter in the houses, and from the meter it is conveyed by still smaller pipes to the different parts of the house.

e. As the gas passes through the meter it is measured in such a way that every cubic foot which is used is registered. The diagrams will illustrate how this is done.



By the time that the hand of dial No. 1 has passed once round 100 feet have been used, and the hand of dial No. 2 has moved to 1. When this hand has passed once round 1000 feet have been consumed, and the hand of dial No. 3 has moved to 1; and when this hand has moved once round the dial 10,000 feet have been used, and the hand of dial No. 4 will have moved to 1; and when that hand has moved once round its dial 100,000 feet of gas have been registered. The quantity consumed, according to the above register, would be 11,110 feet.

All gas consumed is paid for by measure, 1000 cubic feet costing in the north of London at the present time (1883) 3*s.* 2*d.*

The quantity of gas used in London in 1881—latest return—was

20,230,000,000 cubic feet, which is equal to a bulk of 1 square mile by 726 feet high, and its cost to the public was £2,911,000.

(5) Tell the children that the coal tar which is obtained in the manufacture of gas contains many valuable substances, and these are got out by a process called *distillation*. If possible show some, and, if children are old enough, give a brief account of the mode of extracting them.

a. The coal tar is put into a still, and heat applied. All the volatile portions pass off as vapour, and are afterwards condensed, forming a spirit oil called *coal naphtha*. The solid portion remaining in the still when cooled is a kind of pitch.

b. The coal naphtha is again distilled, and produces another spirit oil called *benzole*.

c. This benzole is dissolved in nitric acid (aquafortis), and produces a substance called *nitro-benzole* (an artificial oil of almonds).

d. The nitro-benzole is next mixed with lime and acetic acid, and produces a substance called *aniline* (a dye).

e. This aniline, when acted upon by the oxides of metals, produces those beautiful colours known as *mauve*, *rosaline*, &c.

IV. Different Kinds of Coal.—Provide specimens of various kinds of coal (any coal merchant will supply them), let the children touch them, when they will see that some soil the fingers, others do not. If there is a fire in the room put a small piece of each on it, and draw attention to the difference in the burning, and so work out the following classification.

1. BITUMINOUS COAL:

(1) *Pitch or Caking Coal*, such as is obtained from the Newcastle coal-fields.—This kind of coal, when first heated, breaks into small pieces, which as they get hotter unite into a solid mass. It burns readily, with a lively yellow flame, but requires frequent stirring to prevent its caking, and so clogging the fire.

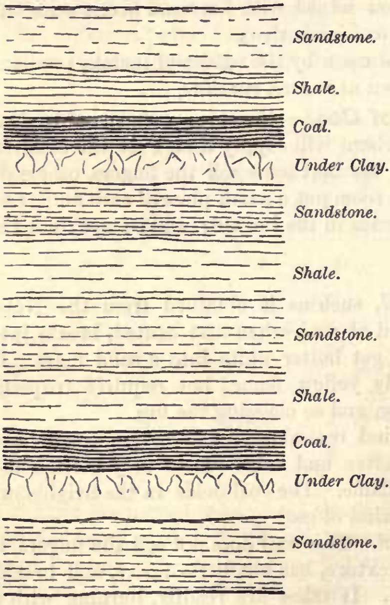
(2) *Cherry Coal*.—This kind resembles pitch coal in colour and appearance, but does not soften and cake. It is very brittle, and burns with a clear yellow flame. The coal-fields in the neighbourhood of Glasgow yield this kind of coal.

(3) *Cannel* or *Candle Coal*.—This coal does not soil the fingers, is very compact and even in texture, has but little lustre, and breaks with a large shelly fracture. It takes fire readily, burning with a clear yellow flame, and does not cake. It will take a fine polish, on which account it is sometimes made into inkstands and other useful articles. Cannel coal is found in the neighbourhood of Wigan.

(4) *Brown Coal*, sometimes called *Boghead Coal*.—This coal is of a

brownish-black colour, and is destitute of lustre. It readily takes fire, and when burning gives off a peculiar odour. It is found in some parts of Devonshire, and near Bathgate in Linlithgowshire, Scotland. From Boghead coal is obtained *paraffin oil* and the beautiful white substance known as *solid paraffin.* See lesson on CANDLES.

2. NON-BITUMINOUS COAL.—*Anthracite.*—This coal is sometimes called *glance coal* and *stone coal. Blind coal* or *culm* are terms sometimes applied to the same substance. Anthracite is very compact and hard and lustrous. It burns without flame and smoke. It neither cakes nor forms a cinder. Not burning so readily as the other kind of coals, it is more fitted for furnaces and closed stoves than for open grates. Anthracite is found in the Welsh coal-fields, and hence it often goes by the name of *Welsh coal.*



Strata showing Seams of Coal.

V. Where Coal is found, and how it occurs:

1. *Where found.*—If the children have had the "Coal-fields" in connection with Geography, recapitulate; if not, show map of Great Britain, and point out the districts in which the most important and extensive deposits are found—namely, (1) those of the great northern district, including all the coal-fields north of the Trent; (2) those of the central district, including Nottingham, Leicester, Warwick, Stafford, and Shropshire coal-fields; (3) those of the western district, including North Wales, South Wales, and Gloucester; (4) those of the eastern and western districts of Scotland; and (5) those of Ireland.

2. *How Coal occurs.*—Show diagram of a section of one of the coal-fields. Point out which lines represent coal, and thus lead children

to see that it occurs in a number of layers or beds more or less horizontal. These layers, termed *seams*, are separated from each other by layers of stone. Compare with way in which metals occur—in veins more or less vertical. Immediately under each seam of coal there is a layer of clay, termed the *under clay*, and above it a layer of shaly clay or shale; between the seams are layers of coarse, hard sandstone. Under the lowest seam of coal is a layer of limestone, which extends beyond the coal-field, and rising to the surface of the ground around it, forming hills, and hence called *mountain limestone*. The whole of these rocks when spoken of collectively are called the *coal-measures*.

The seams of coal are, in comparison with the rocks that separate them, very thin, varying from a few inches to a few feet, the thickest being a seam of 30 feet in the Staffordshire coal-field. In the Forest of Dean coal-field there are fifteen seams, separated from each other by layers of rock of varying thickness. The first seam is 830 feet below the surface of the ground, and the last is 2397 feet. The thinnest seam is but 8 inches, and the thickest is 5 feet. In the Staffordshire coal-fields there are thirty-seven seams, seventeen of which are too thin to be worked. In the Newcastle coal-fields there are sixteen seams, the thinnest being 18 inches and the thickest 6 feet. There are two such seams separated from each other by 341 feet of rock.

VI. How the Coal is obtained.—By reference to the fact that coal is always associated with certain kinds of rocks the children will see that its *probable* existence will be determined by the presence or absence of those rocks.

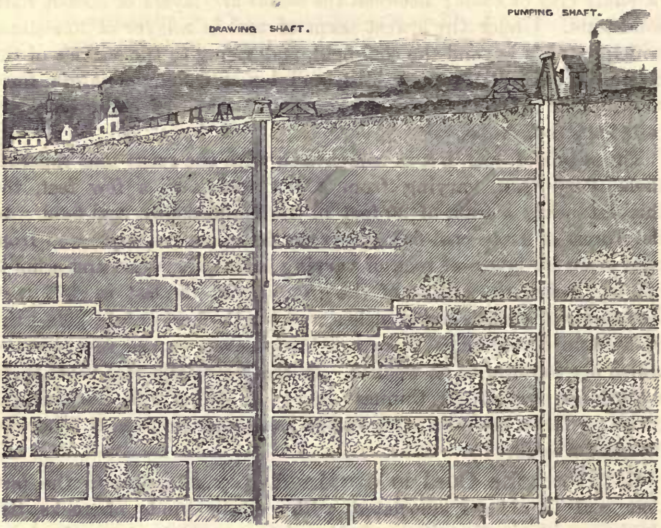
1. *Boring for Coal.*—Let the children suggest a plan for ascertaining the actual presence of coal in any particular place—namely, to bore into the earth and notice what substances are brought up in the instrument. Make diagram of the tools, and illustrate.

(1) Bore rods with screws.

(2) Chisels fitted with screws made of well-tempered steel. These are worked either by hand or by machinery. As the bore-holes are made they are lined with tubes. The chisel is worked by sudden lifts and falls, and after a time it is withdrawn, and another instrument called a *wimble* is lowered, and the material which the chisel has separated from the rock is brought to the surface. When the presence of the seams of coal has been ascertained then they must be reached. How?

2. *Sinking the Shaft.*—Dig down, as in making a well. This called *sinking the shaft*. Draw section of a mine, as in diagram, and

explain that this work is performed by men called *sinkers*, who, as they dig out the earth, line the sides of the shaft with wooden planks or iron tubbing made in segments and fastened together. The object of this lining is twofold—first, to keep the sides from falling in, and second, to keep out the water which is met with, and which gives the greatest trouble to the sinkers. In one shaft sunk in Durham three springs were met with; the first gave 2000 gallons of water a minute, the second 1000, and the third 1600, making a total of 4600 gallons a minute. The operation of sinking is continued until such seams of coal are reached which are thick enough to work. One of the most remarkable shafts sunk in this country was that of the Pemberton mine, Monkwearmouth. The first coal was reached at 344 feet below the surface, but the main seam—the *Maudlin*—was found at a depth of 1578 feet, and the *Hutton* at 1800 feet. The cost of the shaft was nearly £100,000.



Section of Coal Mine.

3. *Excavating the Coal.*—Supposing the desired seam of coal reached, let the children say what must next be done. Cut it out. Show ground-plan of a mine, and explain the process:

a. A broad, straight passage, called a *bord*, or *mother gate* (that is, a principal road), is driven from the shaft into the seam of coal in opposite directions. This passage is from 12 to 14 feet broad, and the whole height of the seam, so as to expose the rock above, which is now called the *roof*, and the stratum below, which forms the floor.

b. When a bord has been excavated some distance narrow passages called *headways* are driven from it at regular intervals on both sides, and at exactly right angles; and when these have been driven 8 or 10 yards they are made to communicate with other bords, which are opened parallel to the first, and on each side of it. In this way the bed of coal is entirely laid open, and intersected by broad, parallel passages about 8 yards apart, communicating with each other by narrower passages or headways, which cross them at right angles, and also traverse the whole extent of the mine, breaking up the seam into immense squares. In this state a coal-mine may be compared to a regularly-built town, the bords being the principal streets, and the headways the narrower streets which cross them, while the pillars of coal form the masses or blocks of buildings.

c. When the whole of the seam has been thus cut through the pillars or blocks of coal are next removed, of course commencing with those farthest from the shaft; while this coal is being removed wooden props are put up to support the roof. In time these pillars are removed, and then the unsupported roof of the mine falls in. The heap of ruins thus occasioned is called a *goaf*.

d. The coal is cut away by men called *hewers*, who first dig some from the bottom of the seam by means of a pick-axe, and then by sudden thrusts of the pick at the top of the seam remove great masses, which fall on the floor. (This work is now, in some mines, done by a machine.)

e. The hewer, having thus brought down a mass of coal, next puts it into a small truck, and when this is full it is pushed along the passages by boys who are called *putters*. The doors which separate the passages are opened and shut to allow the putters to pass; the boys who perform this work are called *trappers*.

f. When the putters reach the principal headways they give the full trucks to other boys or men, who fasten them to each other, and along these roads they are drawn by horses to the bottom of the shaft, and thence raised by means of a steam-engine to the surface.

4. *Ventilation of the Mine.*—Question out the two reasons why mines must be ventilated:

(*a*) To supply pure air for the miners to breathe; and (*b*) to carry away the gas which escapes from the coal. Illustrate the principle of ventilation. Procure a tall glass vessel (such as are used by sweetmeat dealers). Cut a strip of thick card-board of such a width as will just fit the vessel, and so divide it into two portions, taking care that about two inches of space is left at the bottom of the vessel, and let the slip reach several inches above the top. Fasten a small piece of lighted candle to a wire and lower it on one side of the partition. Take a piece of smouldering brown paper and hold it over the half of the glass in which there is no candle. Children will see the smoke carried down that side of the glass, pass under the partition and up the other side.

Explain how this is brought about. The heat of the flame raises the temperature of the air, causing it to ascend, and cold air passes down the other partition to take its place. Thus, as long as the candle is kept burning in the vessel there is a current of air passing down, supplying the flame with oxygen, and then passing up the other side.

It is on this principle that the mine is ventilated. Two shafts are made at some distance from each other, or, if two cannot be made, the one is divided into two in the same manner that the glass jar is divided. In some part of one shaft a fire is kept burning, and the passages are so connected by doors, that there is a communication with the other shaft; as the air in the fire-shaft ascends, the air in the other shaft descends and passes through all the passages, so supplying the miner with pure air. In the mine in which the author obtained his practical knowledge of the subject, the current was so great that he was glad to button up his coat for warmth sake.

Children will know that coal gas, when mixed with air, is very explosive, and therefore will see that some provision must be made to prevent such explosions in the mine. By diagram show that the foul air of a mine is led into the upcast shaft at a point *above* the fire, and when at work the miners use a *safety-lamp* (the discovery of Sir Humphry Davy). Show picture and illustrate the principle of its action. Place a piece of wire-gauze on the flame of a candle; it will not allow the flame to pass through until red-hot. So lamp is constructed with a covering of wire-gauze to surround the flame. If gas is present in a mine it will pass through the gauze, but the flame will not pass outward so as to communicate with the gas in mine. The lamps are lit and locked before they are taken down the mine.

5. *Management of the Pit.*—Tell this to elder children. In the management of a coal-mine the following officers are engaged:

(1) The *resident viewer*, who is the chief, and to whom all other officers are responsible.

(2) The *under viewer*, whose duty is to make personal visits to

the mine and receive reports, and communicate these to the resident viewer.

(3) The *overmen*, who have the charge of workings of the pit and the safety of the men.

(4) *Deputies*, whose duty is to assist the overmen by visiting each part of the pit before the miners commence their work, and examine and lock the safety-lamps before they are given to the men.

(5) *Master wasteman* and his assistants, whose duty it is to visit all the old workings of the pit, examine the air-courses, and pay general attention to the ventilation of the mine.

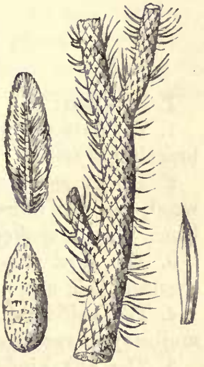
The number of persons employed in and about a coal-mine is very great; in that referred to above the staff consisted of 12 superior officers, 204 workmen above pit, and 316 men and boys in the pit, making a total of 520 individuals.

VII. Nature of Coal.—Show diagram of the plants which are found in the strata immediately above and below the coal-seams, and refer to the inflammable nature of coal, and work out the following facts:

1. That though coal is found in the earth, and is considered as one of the mineral productions of our country, it is not a mineral substance in the same sense as slate or marble, but is of vegetable origin —trees, ferns, &c.

2. These plants have been mineralized by pressure and heat, aided by time. The effect of heat and pressure on vegetable substances can be illustrated by the fact, that if hay is stacked before it is properly made, it will char, and even take fire if exposed to the action of the air. Now, as the coal-seams are found at a great depth, and as the temperature of the crust of the earth increases 1° C. for every 90 feet, the heat would be sufficient to mineralize the plants, and as there could be no exposure to the atmosphere the change would be complete.

3. The coal-plants were of a different character to those which grow in the same locality at the present day, being mostly endogens and acrogens. Hence the conclusion is drawn that there must have been great climatic changes in this part of the globe since the time when such plants were indigenous. The causes which produced the change are, however, not clearly understood.


Coal Plants.

VIII. National Importance of Coal:

1. *As seen in the quantity obtained in one year.*—The following statistics are taken from the latest parliamentary returns: Number of collieries in the United Kingdom, 3813; of these 2673 are in England, 635 in Scotland, 454 in Wales, and 51 in Ireland.

The total quantity of coal in 1890 was as follows:—England, 132,492,320 tons; Wales, 24,741,112 tons; Scotland, 24,278,589 tons; Ireland, 102,267 tons; grand total, 181,614,288 tons; value at the mines, £74,953,997. In the same year there were brought to London by sea, rail, and canal, 12,761,961 tons; and 27,504,911 tons were exported to foreign countries.

2. *In the bearing it has on other industries*, namely, on the smelting of metals, the baking of clays, the manufacture of gas and its associated products, the production of steam, and artificial heat for domestic purposes.

In view of these things it may not be out of place to quote the following lines:—

> "Let foes but steal our cash, and then
> They'd leave us what we were—brave men.
> But could they filch our mines of coals;
> They'd steal our bodies, selves, and souls;
> 'Tis coal that makes our Britain great,
> Upholds our commerce and our state."

Lesson 105.—WOOD.

Notes.

I. Nature:

1. Wood is the fibrous matter which forms the roots, trunk, and branches of trees.

2. The arrangement of the fibres is not the same in all kinds of wood, and this causes some to be harder and heavier than others; hence wood is spoken of as being *hard*, *half-hard*, and *soft*.

3. The *hard* wood comprises oak, beech, birch, elm, box, sweet chestnut, ash, nut, plum, and pear.

4. The *half-hard* kinds of wood are: maple, acacia, apple, alder, mulberry, horse-chestnut, larch fir, and Scotch fir.

5. The *soft* kinds are: fir, pine-wood, lime, aspen, poplar, and willow.

II. How each kind burns:

1. The hard kinds of wood burn with flame for some time on the

surface only, whilst the interior mass is turned into a kind of charcoal. As soon as this change is complete the flame disappears, and the remaining compact charcoal burns without flame.

2. Soft wood produces flame during the whole period of combustion, and very little charcoal is produced. The resinous kinds of fir-wood yield the longest flame.

3. Freshly hewn wood contains a very large amount of water; the harder kinds about 35 per cent in winter, and 40 in summer.

4. When wood is exposed to the action of the air for a long period, say about a year, it loses a considerable portion of its water, but not nearly the whole. Common firewood as sold contains about 25 per cent of water.

III. The Value of each kind as Fuel:

1. The value of each kind of wood as fuel will depend on whether a glowing fire is required or much flame. If used for simply heating a room, then that which will burn with little flame will be the best; but if the object be to heat water for the sake of the steam, then those kinds of wood will be most advantageous that produce the most flame.

2. For the former purpose logs of oak, beech, and birch are the best, and willow and aspen the worst. If for the latter purpose, then mulberry, fir, and ash are the best, and alder, willow, and poplar the worst.

3. Wood, on being burnt, leaves a small amount of ash, varying from 1½ to 2½ per cent, according to its kind and age: thus the trunk wood of an old oak gives more than a young one, and the trunk of both more than the branches. The greater portion of the ash consists of potash and soda, both of which, being alkaline substances, can be used with advantage in washing, &c.

Lesson 106.—CHARCOAL.

Notes.

I. Qualities and Uses:

1. Charcoal is of a bluish black colour, is glistening, and breaks with a glossy, shell-like fracture (conchoidal).

2. It has the shape and structure of the wood from which it was produced. When struck, it rings; if well charred, is hard, and does not soil the fingers when fresh fractured.

3. It contains more or less cracks in all directions, but most of these cracks run from the centre as radii.

4. It is brittle and friable.

5. Charcoal is porous, and absorbs both water and air from the atmosphere, causing it to increase in weight from 8 to 15 per cent, according to its compactness. Charcoal in the form of powder absorbs twice as much water as when in pieces. Charcoal from which all the moisture and air have been driven off has the power of absorbing all kinds of gases in a very large degree. The author once witnessed some very interesting experiments, performed by Professor Goodeve of King's College, to test this property. A number of pieces of charcoal were heated to redness, and allowed to cool without coming in contact with the air. When cool they were instantly plunged into glass tubes filled with various gases, the open ends of the tubes being placed in cups of mercury, the lump of charcoal resting on the surface of the mercury. In a short time the mercury began to rise in the tubes, thus showing that the charcoal had absorbed the gases. Ninety per cent of ammoniacal gas was thus absorbed—55 of sulphuretted hydrogen and 35 of carbonic acid.

6. This property of absorbing gases can be turned to good account by inclosing some pieces of fresh heated charcoal in an iron box so constructed as to fit over the sink traps in our houses, having, of course, some small holes on the side of the box which is placed on the trap.

7. Charcoal is more difficult to ignite than wood, but when ignited it burns steadily without emitting smoke, and, when in small pieces, without flame also. Large pieces burn at the commencement with a little shiny flame, owing to some combustible gas which it contains in its pores.

8. The fumes given off by charcoal in the process of burning are very poisonous; it ought, therefore, never to be used in rooms unless great care is taken to lead these fumes away.

9. When fully ignited charcoal, weight for weight, gives off about 1½ times as much heat as soft coal, and more than twice as much as that of wood.

II. How made.—The most common way to make charcoal is as follows:—The wood—oak, beech, birch, hornbeam, or fir—having been cut into portions of convenient size, a piece of ground is levelled at some suitable spot in the forest; this space is called the *hearth.* In the centre of this three upright stakes are driven in, about a foot from each other, and so secured that they may resist pressure.

Pieces of wood of equal length are piled concentrically round the stakes, placing those nearest the centre almost vertically, and giving the surrounding pieces a slight, but gradually increasing inclination. A second row is stacked in a similar manner above the first. All the interstices are filled with small branches. The top of the pile is covered with a layer of the same kind of wood placed horizontally, and radially, so that the whole pile, when finished, is in the form of a flattened cone.

Close to and around the base of the pile a row of forked sticks are driven in, with the forked ends uppermost, and about six inches out of the ground. The pile is next encircled with a band of branches resting in the forks of these sticks.

The whole of the pile *above the band of branches* is now covered—except the space at the top of the three central stakes—with turf, the grassy side being placed inwards. The turf is next plastered over with a layer of earth. The pile is now ready for lighting, which is accomplished in the following manner:

The space within the three central stakes, or chimney, is filled with easily inflammable wood, which is then ignited, and the fire is kept up by a supply of fresh wood or charcoal until the centre of the pile has become thoroughly kindled. The chimney is well filled with small dry wood or charcoal, and effectually stopped by extending the turf and soil covering entirely over it and pressing it well down.

During this process a considerable quantity of water condenses in the cover and escapes at the base of the pile.

When all the moisture has been driven off—or the *sweating*, as it is called, is over—the foot of the pile is covered with earth, and the whole covering made impervious to the air, and the pile is left to itself for three or four days.

At the end of this time holes are made round the pile on a level with the top of the first row of wood. Thick yellowish-gray smoke at first escapes from these vents, but after a time it becomes bluish and nearly transparent. When this is the case the vents are stopped and another row below them is opened, when the same change in the appearance of the smoke ensues.

When only bluish transparent smoke issues from these lower vents they are closed, and every part of the cover is made impervious to the air, and the pile is left at rest during a few days. If left alone, in the course of time the fire within would be perfectly extinguished. It has been found, however, that in that case the charcoal is less serviceable as fuel than when it is withdrawn hot and rapidly extinguished, so the pile is opened on one side near the bottom, the pieces which are found perfectly charred are withdrawn and quenched, either by putting them in water or by covering them with dry soil.

Lesson 107.—COKE.

I. The two kinds of Coke used:

From the lesson on Gas the children will know that the substance left in the retort is coke. It is called *gas-coke* or *soft coke*. If possible procure a piece of furnace or foundry coke, and compare; the latter hard, compact, of a light gray colour, and has a kind of metallic lustre; the former soft, spongy, light, and rather black.

Tell that the furnace or hard coke was made from coal, but that the coal was burnt for the sake of the coke, while the soft coke was made from coal which was burnt for the sake of the gas which it contained.

The hard coke requires a greater amount of air to ignite than the soft, but when ignited it gives out more heat, and burns for a much longer time than the gas-coke; on account of this it is used in the smelting of ores and melting metals.

II. How made:

1. *The Oven.*—In its simplest form a coke oven is a chamber of fire-brick, having an arched roof in which is a hole, and an entrance below. (If the teacher has seen a brick oven such as is used in some parts of England for baking purposes, he will be able to illustrate the point.)

2. *The charge.*—The oven is first heated to redness, then small refuse coal is thrown in through the hole in the top. When the coal reaches to the springing of the arch, it is levelled with an iron rake, and the doorway built up with loose bricks. In two or three hours the lower rows of loose bricks are plastered up with clay. After the charge of coal has been in the oven twenty-four hours, the top row of bricks is also completely closed.

At the end of another twelve hours the top of the chimney is also closed, so that all communication with the atmosphere is now cut off, and in this state the whole remains to complete the operation. The doorway is then opened, and the coke is raked out into low iron wagons, and carted away and extinguished with water.

Coke made in this way is in long strips of various sizes. It is sold in London by weight. Its price at the present time is 31*s.* per ton.

SECTION IV.—COMMON NATURAL PHENOMENA.

LESSON 108.—RAIN AND CLOUDS.

I. Introduction:

1. Supposing the lesson to be given on a thoroughly wet morning, let the children describe the phenomena. The whole sky obscured by a continuous cloud of a dull grayish white colour. From this cloud the rain descends in drops, which fall in straight lines, more or less vertical according to whether or not the rain is accompanied with wind.

2. Compare present rainfall with any other which has recently occurred, and so bring out that the size of the drops, the rapidity with which they fall, and the quantity of rain which falls within a given time, varies, being greater on some occasions than at others; and varying also in the length of time, and in extent of space over which it falls. Thus there are continuous rains, and showers, as they are termed; and the showers are general or partial, *i.e.* falling only over very limited areas.

II. The Formation of Rain:

1. *Evaporation by Heat.*—If the children have had the lesson on HEAT or on the BAROMETER, recapitulate so much of either as refers to evaporation. If the idea has not been worked out proceed thus: Boil some water before the class in the manner suggested in the lesson on HEAT. Call attention to the fact that heat causes the water to pass off in an invisible vapour. When this vapour comes in contact with the air it forms a mist, which is generally called *steam.* Lead the children to notice that the vapour rises in the air, and is ultimately mixed with the air. Why is this? The heated particles are lighter than air, and so rise, and are absorbed by the air. This act of water passing off in vapour is called *evaporation.*

If the teacher has no means of boiling the water in the manner suggested get a wet cloth, dry it in front of the fire, and question on what takes place.

2. *Condensation of Vapour by Cold.*—Hold a cold dry glass in the vapour as it is rising, and question on what occurs. The surface of the glass is covered with a thin coating of moisture. What is its source? The vapour. So when vapour of water comes in contact with a colder medium than itself it passes into water again. This is called *condensation.*

3. *Application to the Formation of Clouds:*

(1) Question out the following facts:—*a.* The oceans which surround the land, and the surface of the land with its lakes and rivers, are the sources of vapour. *b.* The sun is the source of heat, causing evaporation to take place either by the direct action of its rays or indirectly by warming the air, and so the evaporation from the surface of the ocean and of the land is continuous, but varying with circumstances —more by day than by night, and more in summer than winter.

(2) Refer back to the early part of the lesson. Vapour of water being lighter, bulk for bulk, than air (if a volume of air weigh 1000 oz. a similar volume of vapour of water will weigh only 623 oz.), vapour therefore ascends, and remains invisible until partially condensed. Apply this. The vapour caused by the heat of the sun or air rises until it reaches a cold stratum of air, when it condenses and forms clouds. If the condensation takes place at the surface of the earth then it forms what is called a mist or fog. *A fog is a cloud resting on the earth; a cloud is a fog floating high in the air.*

(3) Again, place a cold glass in the partially condensed vapour, let it remain for a few minutes, children say what they observe. The vapour is wholly condensed, and is turned into water, which runs off its surface. Apply this to the formation of rain. When the air is full of moisture, and the temperature is lowered by cold winds or discharge of lightning, &c., the vapour which forms the clouds is wholly condensed, and water is formed. As this is heavier than air it falls to the earth in the form of rain.

III. Uses of Rain:

1. *Fertilizes the Earth.*—Question out the effect of heat on soils. Causes the moisture to evaporate; ground thus becomes dry. Refer to what plants require to keep them alive. This moisture supplied by rain. Where there is no rain there no vegetation. Give examples.

2. *Supply the Springs with Water, and so feed the Rivers.*—Trace the course of the rain. Some flows off the land into the watercourses, and so passes at once to the rivers, and thence to the sea. Some percolates through the earth, and forms springs. These springs sometimes flow out of the earth, and thus form rivers.

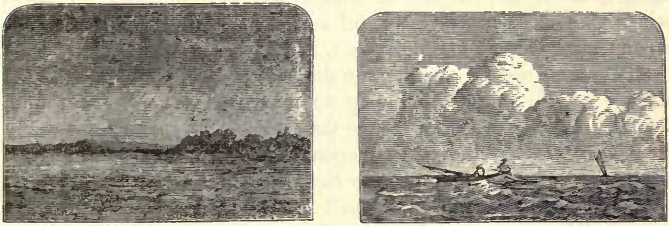
3. *Supply Man with Fresh Water.*—Question on the nature of the water of the ocean. Salt. Man cannot drink it. But the sun and air convert the water into vapour, and this contains no salt. The vapour condenses, and falls in the form of rain, which is pure water. Rain which falls in the country districts is the purest water

which can be obtained, and so the rivers and springs which are supplied directly by rain-water yield pure water.

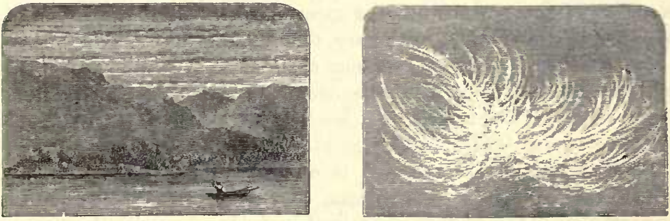
4. *Acts as the Great Purifier in Nature.*—Recapitulate so much of the lesson on Water as refers to this part of the subject, and thus lead the children to see the great benefit of rainfalls in all large towns, washing away, as they do, the dirt which necessarily accumulates, and so rendering such places more healthy than they would otherwise be.

For rainless districts of the earth, and the average fall of rain in this country, consult your *Physical Geography.* For signs of rain see lesson on the Barometer.

IV. The Various Forms of Clouds.—Supposing the teacher to have told his children the subject of the lesson some time



Nimbus. *Cumulus*



Stratus. *Cirrus.*

Principal Forms of Clouds.

previous, and to have asked them to observe the different forms which clouds assume, let them now give the result of their observation. Show diagrams of cloud-forms, and give direct information on the subject.

1. *The Rain-cloud.*—The rain-cloud (as seen on the morning of the lesson) is spread out evenly so as to obscure the whole of the sky. This particular form is called the *nimbus.* These are the great

reservoirs in which water is collected which is afterwards to be dropped on the earth. It is in these clouds that the rainbow is seen. The approach of the rain-cloud is sometimes foretold by small ragged clouds which pass rapidly through the air, and which are called *scud.* They consist of a portion of a rain-cloud broken off by the wind. Because these are usually followed by rain they are called by various names, as *messengers, carriers, water-wagons* or *water-carts.*

2. *The Stacken-cloud.*—These are large masses of clouds which appear to be made up of a number of separate clouds raised or stacked into one mass, often taking the form of mountains whose summits are tipped with silver, the whole floating along with its point to the sky and its lower surface parallel to the horizon. These are called *stacken-cloud* or *cumulus.* These clouds attain their greatest size in the afternoon and evening, and are those which give us the most beautiful sunsets. After the sun has gone down they break up and disappear, leaving the sky clear.

3. *The Fall-cloud.*—As the sun declines a cloud gathers over the surface of the earth, appearing to rise from the lower ground, forming a covering, as it were, to the earth. This cloud is generally formed by the sinking of the vapours in the atmosphere, and so is sometimes called the *fall-cloud* or *stratus.*

4. *Curl-clouds.*—These are small curly clouds, which appear in calm weather at a great height, and extending some distance across the sky. They change their forms rapidly. They are called the *curl-cloud* or *cirrus.* These are the most elevated of all the forms of clouds, and appear to be stationary, though they are not really so.

5. *The Sonder-cloud.*—Sometimes the curl-clouds unite, a mixture of the curl-cloud with the stacken-cloud takes place, one part often being separated from the other. Such clouds are called *sonder-clouds* or *cirro-cumulus.* They form the most beautiful objects in the skyscape.

6. *Wane-clouds.*—These are thin horizontal bands of clouds which rapidly change their form, and give the sky a mottled appearance. They form the *mackerel-back sky* of popular language. On account of the rapid way in which these clouds change their form they are called the *wane-cloud* or *cirro-stratus.* They are remarkable for the great variety of colour they afford, especially in the evening. These clouds precede wind and rain.

7. *Twain-clouds.*—These are large fleecy clouds overhanging a flat stratus or base-like belt, resting on mountains, as it were, there being, in fact, two kinds of clouds. This form is called the *twain-cloud* or the *cumulo-strata.* This form of cloud gives to the sky a very beautiful appearance.

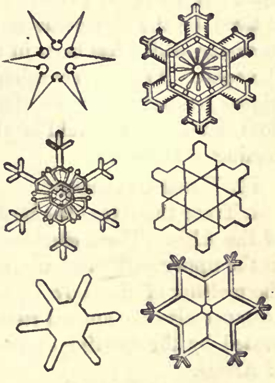
LESSON 109.—SNOW.

I. Qualities of Snow.—If the snow is falling let the children describe the phenomenon. Collect some on a plate, and question out its qualities. The flakes of snow are white. But why white, when water which is its source is colourless? Lead the children to see why this is by reference to the spray of the waves of the sea which is white, and the foam of the waterfall. In both cases the water has been divided into minute particles, and the air has got entangled, as it were, between them. In the same way partially condensed vapour is white, as seen in the steam which issues from the spout of the kettle, the mist which overhangs the valleys, and the thin masses of cloud. So the vapour, which when frozen forms the flake of snow, is made up of very minute portions of water, and the air which is mixed with it gives it the white colour.

Snow is very light. It has been calculated that a flake of snow is nine times[1] more expanded than water, and that it descends three times as slow as rain. A depth of twenty-seven inches of snow in melting does not give more than three inches of water.

The flakes of snow are of an irregular shape and of different sizes. Each flake is made up of a number of crystals. Show picture of some of the forms which the crystals assume. All are, however, hexagonal. Endeavour to excite the children's admiration of such natural beauties.

Tell that the most beautiful and perfect forms fall when the air is calm and very cold, as is the case in the northern regions, and at high altitudes, as on the Alps. Referring to the beautiful forms of snow crystals which he saw at the top of Monta Rosa, Professor Tyndall says: "Nature seemed determined to make us some compensation for the loss of all prospect, and thus showered down upon us those lovely blossoms of the frost; and had a spirit of the mountain inquired my choice—the view or the frozen flowers—I should have hesitated before giving up that exquisite vegetation. It was won-



Crystals of Snow.

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[1] Professor Tomlinson says nine times; Professor Huxley says ten times.

derful to think of as well as beautiful to behold. Let us imagine the eye gifted with microscopic power sufficient to enable us to see the molecules which compose these starry crystals; to observe the solid nucleus formed and floating in the air; to see it drawing towards it its allied atoms; and these arranging themselves as if moved to music and ended by rendering that music concrete."

If the lesson is given while snow is on the ground, question on what the children may have noticed when they made snow-balls. When the frost was very sharp the snow would not adhere together; it acted under pressure somewhat as dry flour does. After a while, however, the heat of the hand caused it to thaw a little, and then it could be bound; the greater the pressure, the harder it became. The children will thus see that snow, after it has fallen, undergoes a change. When it falls in severe weather it is dry; but it afterwards becomes moist, arising from the difference of temperature. Hence it is that the fresh snow that falls near the snow-line of mountains is of a different character from that which falls near their summits; the latter is fine and powdery.

(For the snow-line in Europe and other countries consult your *Physical Geography*).

Tell, or lead the children to see that snow is a bad conductor of heat. If there be a frost at the time of the lesson let its degree be noticed by the thermometer. Next place the bulb of another thermometer, which has been in the school, in some snow, and place it in the open. After a few minutes let a child read it. It indicates a higher temperature than that of the air. How is this? The snow does not allow the cold of the air to penetrate, because it is a bad conductor of heat.

II. Uses of Snow:

1. Trace the rivers Rhone and Rhine to their sources—the glaciers of the Alps. These glaciers are formed by the pressure of the snow in the upper valleys of the mountains. Thus children will see that the melting of the snow on mountains gives rise to numerous rivers. Instance also the annual rising of the Nile, which is supposed to be caused by the melting of the snow on the mountains in the interior of Africa.

2. Being a bad conductor of heat and a bad radiator also, the covering of the plants and earth by snow preserves the vegetation from the effects of severe frosts, and prevents the frost from penetrating the earth.

Tell of Mr. Glaisher's experiment: a thermometer placed on the snow during a severe frost indicated 12° below zero, while another placed under the snow stood at 28°, showing a difference of 40°, so that the plants which were covered with snow were kept much warmer than they would otherwise have been.

3. On the same account the natives of Lapland and of other Arctic regions use blocks of snow with which to construct their houses. The Polar bear also passes his winter hybernation under the snow.

Lesson 110.—HAIL.

I. Introduction.—Question the children as to the season of the year when hail is most usually seen—summer; and under what circumstances—during a storm. Also, as to what they may have observed respecting the hailstones. They differ in shape and size; they more often fall during the day than in the night, and more frequently soon after the hottest part of the day.

II. Formation of Hail:

1. Children will know that hailstones are in reality pieces of ice; and from their usual shape, will conclude that the water which was frozen to produce them must have been in a globular form.

2. Tell that it is generally believed that hail is produced by the rain passing through very cold strata of air, so as to freeze it while it is falling, and that the large stones are formed by two or more smaller ones being driven together by the wind, causing their faces to adhere by freezing (a fact respecting ice which Dr. Tyndall has proved to be true. See lesson on Ice).

3. The fall of hail in the summer may be thus accounted for. When a discharge of lightning takes place there is always a rapid lowering of the temperature of the air, and this, aided by the natural coolness of the air at the altitude of the clouds, causes the rain to freeze, and as the air is often in violent motion during a storm the individual drops may be made to impinge on each other, and so increase the size of the hailstones.

III. Remarkable Hailstones which have fallen.—On the 15th of July, 1808, hailstones fell in Gloucestershire which measured from three to nine inches in circumference. On the 4th of June, 1814, Dr. Crookshanks noticed in North America hailstones of from thirteen to fifteen inches in circumference; they seemed to consist of numerous smaller stones frozen together.

On the 24th of July, 1818, during a storm in the Orkneys, Mr. Neill picked up some hailstones which weighed from four ounces to nearly half a pound. Dr. Malcolmson informed the late Charles Darwin that he saw hailstones fall in India during the summer of 1831, which measured ten inches in circumference. In 1855 Dr. Buist witnessed a storm at Nainee Tal, in which some of the hailstones that fell measured thirteen inches in circumference. During the storm several monkeys were killed, and three human beings were knocked down. In 1860 Professor Tomlinson, when at Leipzig, was caught in a storm of hail; on weighing some of the stones which fell he found they exceeded four ounces.

LESSON 111.—ICE.

I. Qualities:

1. Procure a block of ice, and lead the children to discover its distinguishing qualities. Tell what cannot be observed, and so teach the following facts: Ice is colourless in small masses, but greenish in large;[1] when pounded it is white. It is brittle, splitting easily when struck with a sharp-pointed instrument—a needle or bradawl. Lighter than water. A bad conductor of heat, and a good conductor of sound.

2. Refer to the lesson on SNOW; each flake made up of crystals. Tell the fact that although ice does not ordinarily exhibit well-defined crystals, it is nevertheless built up of crystalline particles interlaced together. Enlarge the sketch of ice-flowers, and explain the method of making them visible. A block of ice is placed in front of a sunbeam or to the beam of electric light, and its image thrown on a screen. Part of the heat from the sun or electric current enters the solid ice and produces internal liquefaction, which proceeds with great regularity. Small shining points first appear in the ice, and round each of these points, as a centre, six rays shoot forth, producing figures such as those represented, and which it was the author's privilege to see produced in a lecture on "Heat" given by Professor Tyndall. Speaking on this subject the professor says: "These beautiful forms, which commonly resemble blossoms with six petals or floral leaves, are not solid crystals, like the crystals of snow, but are simply hollow spaces of regular shape filled with water; they may indeed be called 'negative' or 'inverse' crystals, developed by the breaking-down or decrystallization of the ice. The ice is *crystalline*, whilst snow is *crystallized*."

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[1] **During one of the writer's vacation rambles he visited the ice cavern of the Upper Glacier at Grindelwald. Though the ice above was more than 170 feet thick the cavern was lighted up with a beautiful soft-green light, and the whole mass of ice above was of the same colour.**

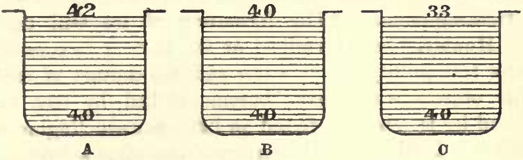
3. When water freezes it excludes all foreign matters, so that the water produced by melting ice is very pure. On freezing, the water also parts with much of the air which it contained. When ice is thawed it absorbs air very rapidly.

4. Ice expands and contracts by cold more than twice as much as any other solid.

5. When two even surfaces which have just begun to thaw are placed together the two weld and become one piece. This will not, however, take place if the temperature of the ice is below 32°. This union of pieces of moist ice is called *regelation*, or freezing over again. This property of ice enables it to be moulded by pressure into various shapes.

II. Formation of Ice:

1. If the children have had the lesson on Water recapitulate as much as is necessary—namely, its expansion by heat from 39° upwards[1] and by cold from 39° downwards to 32°. Water, therefore, attains its maximum density at 39° and its maximum size at 32°. Illustrate this, as in accompanying diagram. Figs. A, B, C represent three deep glass jars filled with water at a temperature of 50°, and placed in a cold room. Two small thermometers are immersed in the water, one near the surface, the other at the bottom of the jar. As the cooling proceeds the upper thermometer will indicate a higher temperature than the lower one, until the temperature falls to 40°, when the water contracts, becomes heavier, and falls to the bottom of the jar. As the cooling proceeds both thermometers will indicate the same temperature, as in Fig. B. But on cooling beyond that point the upper thermometer will mark the lower temperature, the water as it cools becoming lighter and rising to the surface, as represented in Fig. C.



2. Ice is therefore formed at the surface, and the cold water immediately under it cannot be convected downwards. When water is under the action of a freezing temperature the following phenomena take place:

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[1] Some authorities give 40° as the point.

The water at the surface becoming denser by cold descends; the warmer layer which takes its place at the surface is in its turn cooled, made denser, and sinks. And the process is thus continued until the whole mass of water has attained a temperature of 39° or 40°. And further cooling now causes the water to expand, so that its tendency is not to sink but rise and occupy the surface. In this way the top layer is the first to attain the temperature of 32°, and crystallizes into a thin film of ice, while all parts below it retain their temperature of greatest density of 40°. Now, as neither water nor ice is able to conduct heat with rapidity they have but little tendency to transmit the cold downward. Hence the ice is not only slow in attaining any great thickness, but it also protects the water below from the effect of cold winds and low temperature. It is due to this property that the water of deep lakes in the temperate zones is slow in freezing even in severe winters.

3. There are, however, certain conditions under which ice may be formed at the bottom of a stream and remain there for some time. Such a formation is called *ground-ice.* The formation of ground-ice is due to the action of a running stream mechanically mixing the cold surface water with the warmer water below until the temperature becomes uniform throughout, and so the whole mass is reduced to the freezing-point. "The formation of ice will then," says Professor Huxley, "be determined at the bottom in consequence of the greater tranquillity of the water and the contact of cold stones and other objects which have become chilled by free radiation. This ground-ice is generally found in little masses clinging to stones and weeds; and, when the temperature rises after sunrise, the loose bodies are lifted to the surface by the ice just as if buoyed up with corks. The ice then floats down the river, bearing its little freight of gravel, which is dropped on the bed of the river when the ice is broken up or melted." In this way pieces of rock weighing 8 lbs. or more have been raised from the bottom of the Thames and carried down the river. Salt water freezes at a lower temperature than fresh. For the expansive force of ice, and how to prevent the bursting of pipes in winter, see lesson on WATER.

Masses of ice formed in the upper valleys of mountains are called *glaciers.* For their nature and extent, as also for the nature of icebergs, see *Physical Geography.*

III. Uses of Ice:

1. As most children are acquainted with some of the uses to which ice is put in domestic life, let them be mentioned. Tell what not known, and so arrange into those which are for lowering the

temperature of air, articles of food and drink, and those for the lowering of the temperature of the blood, as when applied by medical men, either internally or externally.

2. Tell that the demand for ice for these purposes has led to a regularly organized ice trade, and also to the invention of machines for the production of ice by artificial means. Give the following facts respecting the ice trade:

(1) The idea of trading in ice first occurred to a Boston merchant named Tudor, who in 1805 shipped ice to Martinique.

(2) In 1833 ice began to be imported into Calcutta, and was sold at 3*d.* per lb., exactly half the price of the Bengal manufactured ice.

(3) America was for many years the great ice-exporting country of the world, supplying chiefly the West Indies, India, and China. The cutting and storing of the ice forms an important industry during the winter months, and is, in fact, an ice harvest. It is estimated that in America 2,000,000 tons of ice are cut and stored annually by companies supplying New York and the middle states. New York city alone consumes as much as 500,000 tons per annum.

(4) A considerable quantity of ice from Wenham Lake, near Boston, was at one time imported into Britain, but the whole supply now comes from Drobak, near Christiania, in Norway. The Norwegian ice is very pure. The total quantity imported into the United Kingdom may be estimated roughly at 150,000 tons per annum, of which the greater part is consumed in London, where it is retailed at from 2*s.* 6*d.* to 3*s.* 6*d.* per cwt.

(5) At the present time Norway is the great ice-store for the Old World, and in 1880 Norwegian ice was sold in the United States more cheaply than native ice.

(6) When the ice arrives in this country it is bought by ice merchants and stored in ice-houses.

LESSON 112.—DEW AND HOAR-FROST.

First—DEW.

I. Introduction.—If the lesson is given in summer (which is the proper time) question the children as to what they may have observed when they walked through the grass after sunset on a warm day, or early in the morning after a clear night. Their shoes were wetted. But the day had been fine, and the grass was quite dry but a short time before. The water has been formed on the grass. It is called *dew.*

II. How Dew is formed:

1. Refer to the lesson on RAIN. Heat causes the water in the earth to evaporate, and this vapour is held by the air. The hotter the day, the greater the amount of vapour which rises; cold condenses the vapour and forms water.

2. If possible procure a glass which has been kept very cool. Bring it into the room; children say what takes place. The sides are quickly covered with water. From whence did the moisture come. The air in the room being charged with vapour, that which came in contact with the glass gave up its store to the cool surface of the glass.

3. *Apply this to the formation of Dew.*—The surface of the earth and the grass receive heat from the sun. When the source of the heat is withdrawn the heat is parted with by radiation (see lesson on HEAT); and as these bodies radiate more rapidly than the air every blade of grass, every leaf, or pebble presents a cold surface to the air which surrounds it, and to these cool bodies the air gives up its vapour, which is condensed, and forms water—the dew.

No dew is formed until the body which is in contact with the air is cold enough to condense the vapour of water which it holds, and the air itself is reduced in temperature so as not to be able to hold the moisture. The temperature at which this takes place is called the *dew-point.*

4. Work out the circumstances which are favourable to the formation of dew:

(1) A hot day followed by a cold clear night is favourable. When the night is cloudy, the clouds reflect back the radiated heat from the earth's surface, and thus the air is rendered warmer than would otherwise be the case.

(2) The greater the difference between the day and night temperatures the more copious will be the dew. Hence more due is formed in this country in the autumn than in the middle of the summer, and hence, also, more dew is formed in hot countries than in the temperate zones.

(3) Cloudy and windy nights are unfavourable to the formation of dew; but if a cloudy night be followed by a clear cold morning the dew will be copiously deposited.

(4) More dew is formed on open fields than in woods, as every tree prevents the free radiation of the heat. But, as in such spots there is much less evaporation during the day, there is much less need of the dew by night.

III. Use of Dew.—Question as to the effects of great heat on land—great evaporation; the effect of this on vegetation—it droops. But when the loss by evaporation by day is the greater, the deposit of dew by night is more copious, and so the plants receive the moisture which they require. Hence the beneficent arrangement by which the want is supplied.

Second—HOAR-FROST.

Formation:

1. Refer back to the lessons on SNOW and ICE. When water is cooled down to 32° it is converted into ice. Suppose, then, that the nights which follow fine days are rather long and cold, what will take place? The radiation will continue, and the temperature of the atmosphere will be lowered; the dew-point will be reached, and then there will be a still further lowering of the temperature until 32° is reached, when the dew will freeze. This frozen dew is called *hoar-frost.*

2. Children may know that the effects of frost on some plants is very injurious. Hence early flowers are often killed in the spring; as for instance, the blossoms of the peach, the cherry, and other fruits.

3. Refer to the fact that covered spots do not radiate so much as open ones, and thus lead the children to see that, by covering the trees, bushes, &c., at night with matting, the evil effects of the cold may in some measure be prevented.

Professor Daniell says: "Vegetation in this country is liable to be affected at night from the influence of radiation by a temperature below the freezing-point of water ten months in the year, and even in July and August the temperature is sometimes as low as 35°."

Hoar-frost on the windows and on the grass and trees is a most beautiful object, especially when the sun first shines upon it.

A Graduated Series of Lessons on the Sun.

LESSON 113.—THE SUN. (FOR YOUNGER CHILDREN.)

1. The sun is very bright and dazzling; it appears like a brilliant lamp hung up in the sky. The sun gives light by day, and enables man to do his work with comfort. It not only gives light but heat also; its light and warmth cause vegetables to grow, fruits to ripen, and man and all other animals to appear joyful.

2. The heat of the sun softens and melts some substances—fats, ice, snow; hardens others—clay; and when excessive burns up vegetation, changes the colour of the human skin, and sometimes destroys human life—sunstroke.

3. The human eye cannot look at the sun when it is in full shining; when it is seen through a fog or a coloured glass, it appears to be a flat body of a circular form, of only a few inches in diameter.

4. In the morning the sun is seen in the east, at noon in the south, and in the evening in the west. It is said to *rise* in the morning and *set* in the evening, thus causing day and night.

5. Darkness does not follow immediately after the sun has set, nor does the darkness remain until the sun rises; darkness comes on gradually, and daylight comes on gradually. The light which follows the setting, and precedes the rising of the sun, is called *twilight.*

6. The sun does not really rise and set; the apparent motion of the sun is caused by the real motion of the earth on its own axis, which is from west to east, and so causing the sun to appear to travel from east to west. (This can be illustrated by reference to the fact, that when we are travelling in a railway train the hedges appear to be going in a contrary direction.)

God made the sun, and when we feel its warmth we should remember Him and be thankful.

LESSON 114.—THE SUN (*Continued*).

(*Points to be added to the previous Lesson, when Children are more advanced.*)

1. Though the sun appears to be a flat circular body, it is not really flat but a sphere; and although it looks small it is really very large; its diameter is 852,900 miles, or 107 times greater than the earth's diameter, and its bulk is nearly one million and a quarter times that of our globe. Its apparent littleness is the result of its great distance from the earth. The sun's greatest distance from the earth is 92,963,000 miles.

The following illustration may help the children to realize this distance. Supposing it to be possible to journey from the earth to the sun in a railway train, travelling at the speed of 60 miles an hour, and travelling day and night without any stoppages, it would require rather more than *one hundred and seventy-four years to perform the journey.*

2. How wonderful that the sun, which is placed at such a distance from the earth, should yet diffuse its light and heat, render the soil fruitful, and influence animals and man!

3. The sun does not remain above the horizon for the same length of time all through the year; the shortest duration of sunlight is on December 21st—the shortest day, and the longest on June 21st—the longest day. From the shortest day to the longest, the number of hours which the sun remains above the horizon gradually increases, and from the longest to the shortest the number gradually decreases again.

4. The sun rises higher in the heaven every day between December 21 and June 21, and then gradually declines from June 21 to December 21. The heat of the sun is in proportion to the height to which it rises in the heavens.

5. This difference in the length of sunlight and the amount of heat is called the *seasons*—winter, spring, summer, autumn.

This variation in the seasons is not due to the motion of the sun, but to that of the earth round the sun, which is called its *annual motion,* and which is accomplished in 365¼ days (more precisely 365 days, 6 hours, 9 minutes, 10·75 seconds of mean solar time).

God's power and wisdom are seen in the creation of the sun. We should adore Him as the Creator.

LESSON 115.—THE SUN (*Continued*).

(*Matter to be added to the previous, for Elder Children.*)

1. When the sun is examined through a telescope (the eye-piece of which is made of dark red glass) it is found that its face, instead of being uniformly bright, is usually spotted with dark patches.

2. These spots are not constant, either in shape or in position. Sometimes they are altogether absent, and the face of the sun then seems perfectly pure. The spots appear first on the eastern margin of the sun, when they are of a narrow form; they move gradually toward the centre of the disc, becoming more distinct and rounder, and then pass on to the western margin, becoming again narrow and less distinct. About 13 or 14 days are occupied in the passage of the spots across the sun's disc.

3. In some cases the spots appear again on the eastern margin after a period of 14 days. From this circumstance it has been concluded, 1st, that the sun is a sphere; and, 2d, that it moves round its axis in about 26 days.

4. The spots on the sun are cavities in its luminous atmosphere. They are not equally dark throughout; the outer part (*penumbra*) is not so dark as the inner (*umbra*), and the very centre (the *nucleus*) is the darkest.

Sir W. Herschel estimates that the luminous atmosphere of the sun is not less than 1840 miles, and not more than 2760 miles in depth, and that this forms the outermost coating of the sun, or its visible surface. That beneath this there is another, more dense, and highly reflective, which throws back the light of the upper region, and that this lower atmosphere constitutes the umbra of the spots, and that the dark central part, the nucleus, is the solid matter of which the sun's body is composed.

5. The spots on the sun are of different sizes and shapes. The one which was visible to the eye for several days in the week commencing November 17, 1882, was estimated at over 8000 miles in diameter; some have exceeded 17,000 miles.

6. The number of spots varies very much; at times not a single spot is visible for weeks, or even months together, at other times more than a hundred have been observed at once. No spots are ever seen near the northern or southern poles of the sun.

7. Besides the dark spots, others of a bright and mottled appearance have been observed; they generally appear as streaks of light near the eastern or western margins of the solar disc; they are termed *facula*, or little torches.

The sun is in reality one of the fixed stars, and round it a number of other smaller stars are revolving at different distances, and in different periods of time. These revolving stars are called *planets*, of which the earth is one, though by no means the largest.

8. The following are the eight principal planets, arranged in the order of their distances from the sun:—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. They are all retained in their orbits by the force of gravitation exerted by the sun, which forms the great centre of the solar system.

9. At one period of time the sun was worshipped by several races of people, and now is by the Parsees of India. Our word Sunday received its name from the fact that on that day the worship of the sun was conducted by our heathen ancestors.

The Jews commenced their day with the setting of the sun. They expressed the *east* by the term "the rising of the sun," and the *west* by "the setting of the sun," and the *whole earth* by "from the rising to the setting."

10. Connected with the sun are recorded the following miracles:—

Its standing still in the valley of Ajalon, Josh. x. 12, 13; its shadow being put back on the dial of Ahaz, 2 Ki. xx. 11; and its being darkened at the crucifixion of our Lord, Luke xxiii. 44, 45.

In the Scripture the sun, on account of its beneficial influence, is spoken of as illustrative of God's favour and the advent of the Messiah, Ps. lxxxiv. 11; on account of its splendour of the glory of Christ, Rev. i. 16; on account of the clearness of its light of the purity of the church, Can. vi. 10; on account of its brightness of the future glory of the redeemed, Mat. xiii. 43. In its size, and also in its influence, the sun sets forth the power and majesty of God. This is beautifully expressed by the psalmist in Psalm xix.

LESSON 116.—THE MOON.

1. The moon does not shine continually as the sun does. There are moonlight nights, and there are nights when the moon does not shine.

2. The moon does not always appear to be the same shape: sometimes it has a round disc like the sun; at other times its face is but half a disc, like a plate broken in half; at other times its form is like a crescent.

3. When the moon's face is a perfect circle it is called a *full moon;* when only half a circle is seen it is said to be the *first quarter* or *third quarter*, according to whether it is before or after the full moon; the thin, crescent line of light, when first seen in the western sky, is called the *new moon.*

4. These changes in form in the moon's face occur gradually and constantly. From the time when the first thin crescent form of the new moon is seen to the time when the full moon occurs is fourteen days, and the time between the full moon and the next new moon is fourteen days.

5. These different forms of the moon are called its *phases*, and are caused by its motion round its own axis.

The moon is not really flat, as it appears to be, but is a sphere.

6. The moon cannot shine with its own light, for if it did there would always be a full moon. The moon's light is borrowed from the sun. Being a sphere, the moon can have but one half of its body lighted up by the sun at one time, and in its journey round the earth the half which is presented to the sun is not wholly presented to the earth. At the time of new moon the whole is

turned away from the earth; at the quarters only one half is turned toward the earth; while at full moon the whole of the illuminated half is turned towards the earth.

7. It takes the moon twenty-eight days to journey round the earth, and this is the exact time that it takes to revolve round its own axis. On this account the same side of the moon is always seen from the earth.

8. The moon rises in the east and sets in the west, but the time of its rising and setting is not the same every day. The full moon always rises at the same time as the sun sets; and it rises about three-quarters of an hour later every day until the next full moon. This it does all through the year.

9. The moon appears to be about the size of the sun, but this is not the case. It is, in fact, one of the smallest of the heavenly bodies, being one forty-ninth the size of our globe. But it is one of the nearest to the earth, being only about 239,000 miles distant, or *three hundred and eighty times nearer to us than the sun.*

10. The moon's surface is covered with black spots, which are visible to the naked eye, and which cause reflections of light varying according to the position of the moon to the sun. Seen through a telescope they are far more numerous, extending all over the surface, and have the appearance of the craters of volcanoes. They are, in reality, mountains, and they are supposed to be higher than any on this earth.

PART III.

THE ELEMENTS OF PHYSICAL SCIENCE, &c.

SECTION I.—IDEAS OF BODIES. THEIR GENERAL AND SPECIFIC PROPERTIES.

A. The Ideas of Solid, Liquid, and Gaseous Bodies.

LESSON 117.—SOLIDS.

I. Idea:

1. Provide three pieces of wood, one a large cube, one a small cube, and another a cylinder. Let a child try to alter the shape or form of the cylinder into that of the cube by pressure. Children will observe that though the boy is putting forth much of his strength, he is not able to do so. *He is not able to alter the form of the wood.*

2. Next let two of the strongest boys in the class try to twist a bar of wrought iron. They will not succeed. It would take more force than any man possesses to alter the form of the iron: it could only be done by the aid of a machine.

Another boy to alter the form of a piece of stone. Class will see that it requires a very heavy blow with a hammer to do it, and in altering the form the stone has been broken.

Tell that the iron, the wood, and the stone are called *solid bodies.*

3. Having failed in their endeavours to alter the *form* of the substances, let them try to alter their *size*, or *volume* as it is called, by their own pressure. Here, again, they will be unsuccessful. It would require more force than they possess to alter the size of either of these solids. What, then, can they say of solid bodies?

II. Name and Definition.—"*A solid body is a substance which resists any attempt to alter its shape or size: always keeping the same size or volume, and the same shape unless it be acted on with much force.*"

LESSON 118.—LIQUIDS.

I. Idea:

1. Place on the table a glass bottle, also a basin and a jug which hold the same quantity as the bottle. Call attention to the fact that each vessel differs in form.

2. Put a pint of water into the bottle. Children will observe that *the water has taken the form of the bottle, and spread itself out so that its surface is level.* Endeavour to press the water down the neck of the bottle so that more water may be put in. It cannot be done. *The volume of water cannot be altered.*

Next pour the water from the bottle into the basin. The class will observe that the water has filled the vessel, taken its form, and spread itself out so as to make its surface level.

Next pour the water from the basin into the jug. It will be seen that the water has again filled the vessel, taken its form, and spread itself out so as to make its surface level. Because water will do this it is said to be a *liquid.*

3. Some milk now to be substituted for the water, and the same experiments performed. Children will see that what was true of the water is true of the milk. When poured into either of the vessels it keeps its size or volume, takes up the shape of the vessel, and spreads itself out so as to make its surface level.

What is true of water and milk in these respects is true of all other liquids.

II. Name and Definition.—We can therefore say that *a liquid body is one which keeps its own size or volume, takes up the form of the vessel into which it is put, and spreads itself out so as to have a level surface.*

LESSON 119.—GASES.

I. Idea:

1. Place on the table a lamp with a long flexible tube. Fix the tube to the gas burner above the table. Turn on the gas and light the lamp on the table. Children will see that the gas must be passing from the upper burner to the lower through the flexible tube.

2. Bid them observe what takes place when the gas is turned off at the further end of the tube. Directly the tap of the upper burner is turned the flame in the lower one goes out. So while they are sure that when the lamp on the table was burning there must have been gas in every part of the tube, yet as the light went out at the very instant the upper tap was turned there was really but a small quantity of gas in the tube, yet the tube must have had some gas in every part.

3. To make this clearer light the lamp on the table again, and send some one to turn off the gas at the meter. Let it be turned off when

a signal is given. Give the signal, and call attention to what takes place. At the very moment the tap is turned the gas goes out, so that there is but a very small quantity of gas in the pipes, but that quantity fills the pipes. Now this arises from the fact that *however small a quantity of gas is allowed to enter the pipe it at once fills the whole space.* You cannot put just enough gas in the pipe to half fill it, as can be done with sand or water.

What is true of the gas in this respect is true also of the air—any quantity put into any vessel fills the whole vessel.

4. Call attention to a glass full of air, or what is called an empty glass. Hold it upside down, and plunge it into another vessel filled with water. Children will see that the water does not enter the glass. It cannot, because the glass was already filled with air. The water, however, has gone a little way up the glass. The water has really pressed the air closer together. It has made the air occupy a smaller space.

II. Name and Definition.—The gas in the pipes and the air are called *gases.*

What, then, is a gas? *A gas is a substance which has really no surface. Any quantity put into any vessel fills the whole vessel, and any quantity can be pressed into a smaller space than it once occupied.* You thus see that *gases do not keep either their form or their volume.*

(NOTE ON LESSONS 117, 118, 119.—Though these are marked as separate lessons, it will be found that they can be given in connection with each other. They were thus given by the author, and the time occupied was about one hour.)

B. General Properties of Bodies.

LESSON 120.—IMPENETRABILITY.

I. Idea:

1. Mark off on the table a square inch of space, and place on it an inch cube. Call attention to the relation of the cube to the table and the air above it. The cube occupies a certain portion of space at that given time.

2. Require a child to place another cube the same size in the same space at the same time.

Probably he will place the second cube on the top of the first. If he does, call attention to the fact that the second cube occupies a different space.

What then must be done if the second cube is to occupy the same space as the first? Either the second must be made to pass into the first, or the first removed to make room for the second.

But the second cannot be made to pass into the first, and if the first is removed to make room for the second, then it will occupy a different space.

3. Thus the class will see that *a second cube cannot occupy the same space as another at the same time.*

4. Into a glass of water place a large stone. Call attention of the class to what they observe respecting the water. It has risen in the glass. How is this? The stone has pushed some of the water out of its place. The volume of the water rises by an amount depending on the volume of the stone.

Thus the children will see that the stone and the water cannot occupy the same space at the same time. The one cannot be made to penetrate the other.

II. Name.—Tell the children that what is true in this respect of the two cubes of wood, and of the stone and the water, is true of all bodies, *no body can be made to penetrate another so as to occupy the same space at the same time.* This property of bodies is called *impenetrability* (from Latin *in,* not, and *penetrabilis,* penetrable).

III. The Apparent Exception in the Case of Fluids.—Take a certain quantity of water and spirits of wine—measure very exactly. Call attention to volume of each. Carefully mix and then carefully measure the mixture. The volume of the compound is less than the sum of the volume of its constituents. So it *appears* that one body has penetrated the other. Tell that this is merely apparent, not real, and arises from the fact that in both there are interstices or spaces, and the filling up of these caused the difference in bulk.

Lesson 121.—EXTENSION.

I. Idea:

1. Provide a number of objects of different sizes, some large, some of medium size, and some very small. Question as to what can be said of each if they are measured. They all have size or magnitude; they *all occupy a certain portion of space.*

2. In the next place lead the children to see that each object occupies a limited portion of space. Take the cubes. What must be done in order to find out how much space is occupied by each? They must be measured by rule. Do this. One is exactly an inch long,

an inch wide, and an inch thick. Another is exactly half that size, and another only one-fourth.

3. Next take the case of the smaller objects. All have some magnitude. Break some of the pieces of chalk into minute portions, scatter them on a plate of glass. They still have magnitude, and although it is not possible to measure them by an ordinary rule, yet by the aid of a microscope their exact size could be ascertained. However small the particles may be, each will be found to possess some length, some breadth, and some thickness.

II. Name.—Tell the children that what is true of the objects they have been examining is true of all bodies; this property is called *extension or magnitude, and on this account every particle of matter occupies a limited portion of space.*

Tell the children that many instruments have been invented for measuring linear extension with great precision. Two of these, the *vernier* and *micrometer*, are in common use.

LESSON 122.—DIVISIBILITY.

I. Idea:

1. Provide a few pieces of chalk. Class count them—five. Tell the children that you wish each one in the class to have a piece—thirty children. What must be done? Divide each piece into six, when there will be thirty. Do this.

2. Now, suppose thirty more children present, and it is required that each should have a piece. What must be done? Divide each piece into two. Do this. By this the class will see that *each piece of chalk can be divided into other distinct parts.*

Go through the same process with some salt, sugar, &c., when the class will see that each body has the same property.

II. Name.—Tell that what is true in this respect in the case of the chalk, the sugar, and the salt, is true of all bodies. *All can be separated into distinct parts, and because of this they are said to possess the property of Divisibility.*

III. Degree of the Property:

1. Lead the children to see that there seems no limit to the degree of divisibility. Take a lump of coloured matter—say common stone-blue. Pound it. Each particle has extension although its exact size cannot be ascertained by ordinary measurement.

2. Take a grain weight of this powder, place it in a pound of water. Stir it up—the whole is coloured. Now, as the colour is

due to the presence of the stone-blue there must be some of its particles in every portion of the water.

In a pound of water there are 5760 grains. Now, as the one grain of stone-blue put into the water has coloured the whole, every grain weight of water must have its share of the whole, and this share is $\frac{1}{5760}$th of a grain. Tell the children that the colour of our blood is due to the presence of red flattened globules floating in a colourless liquid. When viewed under a microscope these globules can be seen and measured, and it has thus been ascertained that one of these globules is less then $\frac{1}{3500}$th of an inch in diameter, and a drop of blood, which might be suspended from the point of a needle, would contain about one million of globules.

IV. Use of the Property.—This property of matter is of great use to man; by it he is able to reduce all bodies to a required size. Again, very much of the work of the world by which man gains his livelihood depends on this property. *If matter were not divisible there would be no dust, nor would anything which exists wear out.*

LESSON 123.—POROSITY.

I. Idea:

1. Let the children examine a sponge, some pieces of soft wood, and a lump of pumice-stone. They will see that the particles of which the bodies are composed do not touch each other in all places; there are cavities or interstices between them.

2. Weigh a piece of dry chalk, then put it in water. Call attention to what takes place. Globules of air appear on the surface, which afterward rise to the top of the water. Now take the chalk out of the water and weigh it. It is heavier than it was before it was immersed. How is this? It must contain some water. It does, and *this water has passed into the interstices which are between the particles of the chalk.*

II. Name.—These cavities or interstices which separate the particles of matter in a body are called *Pores,* and the body is said to be *porous:* to possess *Porosity.*

III. Sensible and Physical Pores.—Let the children examine very carefully the wood and the pumice-stone, and compare them with the chalk and a piece of metal as to the character of the pores. In the wood and the pumice-stone the pores can be seen; in the other substances they cannot be seen.

Thus the children will learn that there are two kinds of pores: those which can be distinguished by the eye and those which cannot. The former are called *sensible pores*, the latter *physical*.

Tell the children that all bodies possess porosity to a greater or less degree; but in many the pores are physical, not sensible: even gold and the other metals have been proved to be porous.

In the year 1661 some of the learned men of Florence, wishing to ascertain whether water was compressible, filled a thin globe of gold with that liquid, and, after soldering up the opening, they exposed the globe to pressure, with a view of altering the volume of the water. The consequence was that the water forced its way through the gold and stood on the outside of the globe like dew. Since that time the same experiment has been performed with globes of other metals, and similar results obtained.

IV. Use of the Property to Man.—Lead the children to see the usefulness of this property.

1. Show some filtering paper, and explain its use. The pores are large enough to allow the water to pass through, but too small to allow any solid particles to enter. Tell of the use of charcoal for the same purpose. (See lesson on CHARCOAL.)

2. Again. Large blocks of stone are often detached in quarries by introducing wedges of dry wood into grooves cut in the rocks. These wedges being moistened, the water penetrates their pores and causes them to swell with great force—force sufficient to split the mass of rock.

3. Dry cords when moistened increase their diameter and diminish their length. Illustrate how this can be used to raise great weights.

LESSON 124.—COMPRESSIBILITY.

I. Idea:

1. Let the class examine one of the bodies which have sensible pores, say a piece of cork. Measure it in its diameter. It is 1 inch broad. Place the cork in a squeezer. Exert force. Measure the cork again. It is now much less than an inch in diameter. Why is this? The pores have been brought closer together, so that it occupies less space than it did before it was pressed. Its volume is diminished. Do the same with a piece of soft wood; then with a piece of woollen cloth. *Both have been made to occupy less space by pressure.*

2. Show a piece of metal the size of a coin, and a coin. Tell that the latter was at one time like the former. How, then, came

the image and superscription? The plate of metal was put on a die and submitted to pressure. By this means some of the particles of the metal were pressed closer together than they were before.

II. Name.—This property, by which the volume of a body can be diminished by pressure, is called *Compressibility.*

III. Extent or Degree of the Property.—By comparing wool with cork, cork with wood, and wood with iron, the children will be led to see that the degree of compressibility in bodies varies very much.

Tell that *gases possess the quality in the greatest degree, solids next, and liquids the least. In solids the property is found in all degrees.*

In many cases there is a limit to the compressibility, and if pressure is increased the body is fractured, and is reduced to powder.

C. Specific Properties of Bodies.

LESSON 125.—ON BODIES HARD, SOFT, IMPRESSIBLE, PLASTIC.

The objects required for this lesson are some pieces of wood and stone, a small quantity of wool—common flock will do—a vessel of water, a piece of moistened clay, and any of the other substances mentioned in the course of the lesson.

After the objects have been observed and named lead the children to discover how each acts when submitted to pressure. Proceed in the following way:

I. Hardness and Softness:

1. *Idea.*—A boy to place the fingers of his right hand on the stone and the fingers of his left hand on the bundle of wool, press both, and tell the class what difference he observes—what one will do which the other will not. Help the child to express himself properly.

The stone will not yield to the touch; it is *firm,* resisting the force which is endeavouring to alter its form: *the wool will yield to the touch;* it is not *firm.*

2. *Name.*—Give the proper names to these qualities. Because the stone will not yield to the touch it is said to be *hard,* to possess the quality of *hardness:* because the wool will yield to the touch it is said to be *soft,* to possess the quality of *softness.*

3. *Examples.*—Let the same boy touch all the substances on the table, and place them into two groups according to whether they are hard or soft, and say why they are said to be so. Thus the class will learn that cotton, silk, fur, and feathers are soft because they each yield to the touch, while glass, bone, iron, and wood are hard because they will not yield to the touch.

4. *Generalization.*—Tell the children that when they touch any substance and find that it does not yield to the pressure of their hands so that the body resists the pressure put forth to alter its form they may call it hard, and if it does yield to the pressure they may call it soft.

II. Hard and Soft Comparative Terms.—Tell the children that there is another way in which we use the terms *hard* and *soft*, which they shall now learn.

1. Provide some pieces of stone—chalk, sandstone, marble, and granite. Several pieces of metal—lead, copper, and cast-iron. Let a child touch each; as far as they have been taught to distinguish between hardness and softness they would call them all hard.

2. Propose another test, namely, how they resist the action of a knife to scratch or cut them.

Let a boy perform the experiments, and tell the class what he discovers. Among the stones the *chalk* is easily scratched, and so is called a *soft mineral;* the *granite* resists the action of the knife, and so is called a *hard mineral.* Among the metals, the *lead* is easily scratched, and so would be called a *soft metal,* while the *iron* resists the action of the knife, and so is called a *hard metal.*

The children will thus see that hardness and softness are relative terms, indeed relative properties; a body which is hard when compared with one body, may be soft when compared with others.

The relative hardness of two bodies is ascertained by trying which of them will scratch the other. Judged by this standard the diamond is the hardest of all bodies, for it scratches all and is not scratched by any. Talc is one of the softest of the minerals. Soft bodies are worn away by being rubbed against harder ones.

III. Impressibility:

1. *Idea.*—Take the tumbler filled with wool, require a boy to press the wool with a seal, then, without looking at the seal, tell what is engraven on it.

Direct attention to what takes place when the wool is pressed. It occupies less space because it is compressible. When the seal is taken off it has left no mark.

Next require the boy to press the seal on a piece of soft wax.

Having taken the seal off, to say what he observes on the wax—a man's head and some words. Compare this with what is engraven on the seal—the same. Children will thus see that the wax has taken the impression of what is engraven on the seal.

2. *Name.*—Give the proper name to the quality which has been discovered. Because the soft wax will take and retain the mark of the seal when it is pressed on it it is said to be impressible.

3. *Examples.*—Let the children name any substances which will take and retain the marks of a seal when pressed, as wet clay, dough, butter, and some of the metals, as gold, silver, copper, and lead. Next name any which will not do so, as stone, cast-iron, and india-rubber.

IV. Plasticity:

1. *Idea.*—Provide a lump of wet clay, take it into your hand, and form it into the shape of a cup; place it on the table. Take another piece and make it into a ball. Place it by the side of the cup. Make several other forms.

The children will thus see that the wet clay can be made to assume any shape you please, and whatever shape is given it remains when the pressure necessary to give it is taken off.

2. *Name.*—Tell that when a lump of clay is thus pressed into a shape it is said to be moulded. Because the clay can thus be moulded it is said to be plastic, to possess the quality of *plasticity.* Put a lump of gutta-percha into some hot water, when it will become soft. Mould it. Children will thus see that it is plastic. Cool the lump and require a child to mould it in that state. He cannot do so. It is plastic only when warm.

3. *Usefulness of the Quality.*—This quality makes the clay and the gutta-percha more useful than they otherwise would be, as they can be moulded into any shape.

LESSON 126.—ON BODIES RIGID, FLEXIBLE, PLIABLE, ELASTIC.

I. Rigidity, Flexibility, Pliability:

1. *Ideas.*—Provide a thin bar of iron, and a piece of cane exactly the same length and thickness; also a piece of leather—upper leather of a shoe—and a strip of calico the same length.

(1) Let a child stand in front of the class, take each of the objects, one by one, and try to bring both ends together by bending the objects; the other children to say what they observe.

(2) They will see that although the boy is putting forth all his strength he cannot bring the ends of the bar of iron any nearer to each other. *The iron resists the pressure or force; it cannot be bent with the hand.*

(3) Next let the boy take the cane and do with it as he did with the iron. Class to say what they observe. The ends of the cane can be brought a little nearer to each other. *The cane can be bent by the hand, but not very easily.*

(4) In the same way proceed with the thick leather and the calico. When the class will see that the *ends of the piece of leather can be easily brought together,* and that it can be bent easily in any way, and in the case of *the calico* that *not only can it be bent easily, but folded,* and that when folded it remains in the same condition until unfolded.

2. *Names.*—Now give the proper names for these qualities:

Because the bar of *iron* cannot be bent by the hand—not bent without much force—it is said to be *rigid,* to possess the property of *rigidity.* Because the *cane* can be bent by the application of a little force it is commonly said to be *stiff,* to possess *stiffness.* Because the *leather* can be bent with little force, and bent in any way, it is said to be *flexible,* to possess *flexibility;* and because the *calico* can be folded as well as bent it is said to be *pliable,* to possess *pliability.*

3. *Examples.*—Let the class mention other substances besides those on the table which have the same qualities.

Bars of steel, copper, brass, wood, and stone are *rigid.*

Thin plates of the common metals, india-rubber, gutta-percha, and whalebone are *flexible.*

Tin and lead foil, very thin leather, paper, silk, and linen are *pliable.*

II. Elasticity:

1. *Idea.*—Provide a piece of whalebone, a piece of sponge, and a watch-spring. Let a child take the piece of whalebone and bend it. Call attention to the difference in its form. Before it was bent it was straight, when bent curved.

The child now to let go one end of the whalebone. It will assume its former shape. Do the same with the cane and the watch-spring. Both have their form or shape altered by pressure, and both returned or sprung back to their former shape when the pressure was removed.

Next measure a thin strip of india-rubber. It is a quarter of a yard long. Take it in both hands and pull it. It has allowed itself to be stretched. Have it measured again; it is nearly half a yard long, but it is narrower. Let go the end; measure it again. It is the same length and thickness as it was before it was stretched. It has returned to its former shape and size.

Place the piece of sponge on a tumbler. Let a child force it into the glass. He will be able to do this because the sponge is compressible. Take the sponge out of the glass and stand it where it was before. It is again too large to go into the glass. The children will thus see that when pressure was put on the sponge its shape and size were altered, and when the pressure was removed it returned to its former condition.

Call attention to what has been observed:

(1) It required force to change the shape or size of the substances.

(2) It required a continual application of the force to maintain the change in shape or size.

(3) When the force was removed the substance sprung back to its former condition, or previous bulk and shape.

2. *Name.*—Tell the class that because each of these substances has this property it is said to be *elastic* or to possess the property of *elasticity.*

3. *Examples.*—Let the children mention other substances which have this quality, as wool, hair, steel springs, &c.

Tell that every body has some degree of elasticity. It is this property which causes marbles and ivory balls to rebound when thrown on the ground; bells and glasses to emit a sound when struck; and trees to bend when the wind blows.

Tell the class that there are many other points to learn respecting this property when they study science in a higher standard.

LESSON 127.—ON BODIES BRITTLE, TOUGH, MALLEABLE, DUCTILE, TENACIOUS.

The objects required for this lesson are: a thin piece of hardened steel (a long packing-needle will do), a thin sheet of lead or tin, two pieces of iron, one thick and the other thin, and some thick and thin copper wire.

I. Brittleness and Toughness:

1. *Ideas.*—Let the class name the objects as they are held up; ask for a common name which may be applied to the whole metals—*minerals.* Tell that in this lesson they are to discover some of the qualities which belong to this class of minerals.

One of the class to take the packing-needle and try to bend it. The class to observe what takes place. It cannot be bent. When pressure (force) is brought to bear on the steel needle it breaks. Show that each piece into which the needle is broken can be broken into smaller pieces. In the next place let the boy try to break the piece of lead. He cannot. The lead can be easily bent, and bent backwards and forwards many times, before it breaks.

2. *Names.*—Tell because the steel needle can be broken easily it is said to be *brittle,* to possess the quality of *brittleness.* Because the lead will not break easily it is said to be *tough,* to possess *toughness.*

3. *Examples.*—There are other metals besides hardened steel that are brittle, and other metals besides lead that are tough. Show class a piece of the metal called *Antimony* and another named *Bismuth.* Strike each with a hammer; they are easily broken into a number of very small pieces; they are the most brittle of all the metals. Cast-iron and zinc are also brittle.

Show pieces of wrought iron and copper: strike them, they will not break. It is the toughness of some metals which makes them so useful.

II. Malleability:

1. *Idea.*—Provide a thick piece of lead. Strike it with a hammer on a flat-iron. Children say what they observe after the hammering. It is a little thinner and longer. It has suffered itself to be beaten out into a sheet and has not broken. What was done with the hammer could have been much better done had the lead been passed between a pair of steel rollers.

2. *Name.*—Because the lead can be hammered or rolled into sheets it is said to be *malleable,* to possess the property of *malleability.*

3. *Degrees of Malleability.*—Show specimens of iron, copper, and tin which have been rolled out into plates. All these metals are malleable. But all metals are not malleable in the same degree. Show a piece of gold-leaf, it is so thin that it cannot be touched without breaking. It would take *more than seventy thousand of such leaves* laid on the top of each other *to make one inch in height,* and this tiny piece of gold no bigger than the head of a blanket pin could be beaten out to cover a space of 60 square inches, that is, it would cover a sheet of paper 8 inches long by 8 inches broad. Show size. Gold is the most malleable of all metals, and silver the next. Copper and tin are both very malleable. Tin can be beaten out to $\frac{1}{1000}$ of an inch in thickness. The following is the order of degree of the malleability of metals:—Gold, silver, copper, tin, platinum, lead, zinc, iron, nickel.

Cast-zinc is brittle when cold, but when heated to a degree a little above boiling water it is malleable.

III. Ductility:

1. *Idea.*—Show hank of thin iron wire, tell that it was not always thin, it was once part of a bar. It was made thinner by being drawn through holes in a steel plate, or *draw-plate* as it is called. The wire was first drawn through a large hole, then through a smaller one, and then a still smaller, until the wire was thin enough for the purposes for which it was intended. After one or two drawings it was made red-hot or *annealed.* This annealing made the iron soft. Each time the wire was pulled through one of the holes in the draw-plate it became thinner and longer. So that the hank of wire which measures many yards was once a bar not more than an inch in length.

2. *Name.*—Because the iron can thus be drawn out into wire it is said to be *ductile*—to possess the quality of *ductility.*

Show several kinds of wire, the thinnest of each usually sold. Children will see they are not all of equal thinness. The iron and the copper are very thin, the brass and the lead not nearly as thin. It will interest them to know that an ounce of gold can be drawn into a wire 1300 miles long, an ounce of silver into a wire 60 miles long.

The metals stand in the following order as to their ductility:—Gold, silver, platinum, iron, nickel, copper, zinc, tin, lead.

IV. Tenacity:

1. *Idea.*—Take a piece of moderately thin iron-wire, fasten each end to a pencil. Let two boys try to break the wire by pulling. The boys may not be able to break it. Call out two stronger boys and let them try. The class to observe and state what takes place as they pull. They will see that the wire gets a little longer. It is being drawn out because it is ductile, but it *holds together;* the particles of which the wire is composed do not give way.

Tell the boys to exert all their strength when they next pull. Class to notice what takes place. The wire allows itself to be drawn out thinner; at last, however, the particles give way and the wire is broken. It required a great deal of force to cause the wire to break.

2. *Name.*—Because the particles of which the iron is composed hold together, the substance is said to be *tenacious,* to have the property of *tenacity.*

3. *Degree of the Quality.*—Show several kinds of wire—lead, copper, steel. Fasten each at both ends to pieces of wood. Let two boys pull each in turn until it breaks, and tell the class what they noticed about the amount of force required to break them. The lead

required but little force, the copper required much more, and the steel still more. *The children will thus learn that the degree of tenacity is not the same in all metals.*

4. *Use of the Quality.*—It is this quality of tenacity that enables us to draw metals into wire, and the greater the tenacity the finer the wire. And it is this quality which enables the wire to bear a great strain without breaking. Gold wire $\frac{1}{10}$th inch in diameter will hold up 500 lbs. without breaking. Many interesting experiments have been performed on the common metals to determine their relative degree of tenacity. Bars of each metal have been drawn out to equal thickness and then cut into equal lengths. These bars were then fastened at one end to a beam of wood, and weights to the other end, weight being added to weight until the rod broke. By this means it has been discovered that *lead is the least and steel the most tenacious.* If the weight required to pull asunder a wire of lead be taken as unity, that required by similar wires of other metals will be as follows: tin, 1⅓; zinc, 2; gold, 12; silver, 12½; platinum, 15; copper, 18; wrought iron, 27½; steel, 42.

It is this great tenacity of wrought iron and steel which makes those metals so fitted for chains, coupling-irons, and rods for bridges, and for all things which have to bear a great strain.

LESSON 128.—ON BODIES FIBROUS, FRIABLE, GRANULAR, CRYSTALLINE.

The objects required for the lesson are a piece of the stem of the flax plant, a lump of loaf-sugar, a lump of table-salt, and a piece of chalk. Each of the objects to be observed by the children and named.

I. Fibrousness:

1. *Idea and Name.*—Tell the children that all the objects which are on the table are larger than you wish them to be, so they shall be made smaller by being taken to pieces.

First take the stick of flax, and separate the larger pieces into smaller ones. Class will see that *the small pieces that come off are all in the form of threads,* and that these threads run all along the length of the flax. Tell that each little thread is called a *fibre,* and because the flax can be thus separated into a number of fibres it is said to be *fibrous,* to possess the quality of *fibrousness.*

2. *Examples.*—Require the children to pick out other substances on

the table which can be separated into threads in the same way as the flax. Cotton, wool, and whalebone. So all these substances are said to be *fibrous.* Tell the children that if they find any substance which can be separated into threads like the flax they may call that substance fibrous.

It is this quality in flax and cotton which enables us to spin them into yarn and to split the broad plates of whalebone into thin pieces for the frames of umbrellas and other purposes.

II. Friability:

1. *Idea and Name.*—Take the lump of chalk and separate it into small pieces. Children will see that it will not separate into threads like the flax, but as it is rubbed between the fingers and thumb *it crumbles into a very fine powder.* Because it will do this it is said to be *friable,* to possess the quality of *friability.*

2. *Examples.*—Show a piece of dry clay and a piece of very stale bread. Both of these can be crumbled into powder. They are also said to be *friable.* It is upon this quality that the usefulness of chalk as a writing material depends.

Any substance which will crumble and form a powder is said to be *friable.*

III. Granular and Crystalline:

Ideas and Names.—In the next place take the lump of sugar and the lump of salt and strike them with a hammer. Class will see that both have formed a powder. Let a child rub the powdered chalk between his fingers, and then do the same with the sugar and salt, and say what difference to the touch he observes. The powdered chalk feels very smooth to the touch, while the powdered salt and sugar feel hard. Each small piece is rough. Each is called a *grain,* and both the salt and the sugar are said to be *granular.* Here is a piece of sandstone; it will also part into grains, and so it is also granular.

Now let a boy look at the grains of sand through a magnifying glass, and then at the grains of salt and sugar, and say if he observes any difference. Yes. The grains of sand have not any particular shape, while the grains of salt are all of one shape, little six-sided figures called *cubes.* Each of these little grains of salt is called a *crystal;* and because the salt is made up of crystals it is said to be *crystalline.* Here is some beautiful brown sugar. You see that it is also made up of crystals; so it is also said to be *crystalline.*

LESSON 129.—ON BODIES SOLUBLE, FUSIBLE, COMBUSTIBLE, INFLAMMABLE.

The objects required for this lesson are a lump of sugar, a lump of salt, a piece of bees'-wax, a stick of sealing-wax, a plate, some cold water, a tumbler, and a candle, or better still, a spirit-lamp.

I. Solubility:

1. *Idea.*—Pour some water on a lump of salt placed on a plate. Pour a small quantity on at one time. Children will see that the salt has absorbed the water. Pour more water on the lump. Call attention to what takes place.

The *grains* of which the salt is composed *are loosened* from each other, and fall apart.

The whole of the wet salt now to be put into a large glass, and more water added. Children to say what takes place as it is stirred about.

The grains of salt fall apart, and by degrees the quantity of salt at the bottom of the glass becomes less and less until the whole disappears. Let the water be tasted. It is salt. By this we know that the whole of the salt has been taken by the water into itself. The solid salt has by the action of the water become a liquid.

2. *Name.*—Give the proper words which express this quality of the salt. Because the grains of which the salt is composed are loosened from each other by the water it is said to be *dissolved;* and because the salt can be dissolved it is said to be *soluble,* or to possess the quality of *solubility.*

3. *Examples.*—Perform the same experiment with sugar, gum, and soda. All these substances are soluble in water.

Put a piece of camphor in some water and shake it. The camphor does not dissolve. Put another piece into some spirits of wine and shake it. It does dissolve. Here, then, it will be seen that some substances are not soluble in water, but are so in spirits.

Tell the children that *whatever liquid has the power of dissolving a solid is called a solvent of that substance,* and *the liquid which contains the dissolved solid is called a solution.*

4. Next lead the children to see that there is a limit to the power of a solvent. To do this keep putting small quantities of salt into a glass of water, stirring it up as it is put in. After about seven teaspoonsful have been put in no more will be dissolved, and on adding more salt it will sink to the bottom and remain as a wet solid. When this is the case the solution is said to be a *saturated solution.*

II. Fusibility:

1. *Idea.*—Place a piece of bees'-wax in an iron spoon, and hold it over the flame of the spirit-lamp. Call attention to what takes place. First the wax gets soft, then the particles of which it is composed are loosened and fall apart, so that the solid becomes a liquid, and can be poured out. It is said to be *melted* or *fused.*

2. *Name.*—Because the wax will melt with heat it is said to be *fusible,* to possess the quality of *fusibility.*

Now take the lamp away and cool the wax. Children will observe that as it gets cold it becomes solid again. It returns to the same state that it was in before it was melted.

Let the children name other substances which they have seen melted, as tallow, butter, lead, copper, and the other metals. These, then, are all fusible.

3. *The Degree of Fusibility.*—Take some of the fusible substances, put them on an iron plate, and hold the plate over the flame of the spirit-lamp, children carefully observing what takes place. The tallow melts before the bees'-wax, and the wax before the sugar. They will thus see that it takes more heat to fuse some substances than it does others. Tell the fact that many experiments have been performed to ascertain the degree of heat required to melt various solids. Give them in the order from the lowest degree to the highest:—Tallow, phosphorus, wax, sulphur, sugar, pewter, solder, tin, lead, zinc, flint-glass, brass, silver, copper, gold, cast-iron.

SOLDERS.—Refer to the fact that workers in metals often fasten two pieces together by soldering them. Now, the substance used as the solder is also a metal, and yet it melts sooner than the metal which is to be fastened. It is a curious fact that if two or more metals are mixed in certain proportions—say two parts of gold (say dwts.), one-half part of silver, and one-half part of copper—the mixture will fuse at a lower temperature than either of the metals of which it is composed. Such a mixture as this would be called a *solder*—in this case *gold solder.* It is on this principle that all solders are made, and thus all the metals can be fastened together much more securely than they could be by any other method.

III. Combustibility:

1. *Idea.*—Place each of the following substances—cotton, silk, wool, wood, coal—one at a time in the flame of the lamp or on the fire. Children say what takes place. All burn, but not in the same manner. Some burn with a flame and some do not, and all, whether burning with a flame or not, are being consumed. Now put a piece of iron in the fire, children to say what takes place. First it gets

warm, and then red-hot. Take it out of the fire. While it got red-hot it was not consumed. It did not burn.

2. *Name.*—Those substances which will burn are said to be *combustible*, and are said to possess the quality of *combustibility.*

Those substances which are combustible and burn with a flame are said to be *inflammable*, and to possess the quality of *inflammability.*

Those substances which will not burn are said to be *incombustible.*

3. *Degree of the Quality.*—Burn some of the combustible bodies, a child to hold his hand at some distance above the flame and to say what he observes. They give out heat. Thus the children will learn that the production of heat is one of the effects of combustion.

In the next place put a few drops of benzolin in a saucer and apply a lighted match, calling attention to what takes place. The benzolin has taken fire, it is very combustible.

Now pour some good paraffin-oil into another saucer and apply a lighted match. The liquid oil has put out the flame of the match and the oil has not caught fire. Paraffin, therefore, is not so combustible as benzolin. Next place a piece of paper and a piece of wood on the iron plate and hold it over the flame of the lamp. They will see that the paper takes fire sooner than the wood.

4. *Caution.*—Thus, then, children will learn respecting the combustion of bodies that some are much more combustible than others. Benzolin is one of the most combustible substances in common use. On this account it should never be brought near the fire nor should a lamp in which it is burnt be trimmed by candle-light.

Children must remember also that *vegetable substances* are more inflammable than animal substances, and so they must be careful not to bring them in contact with a flame unless they wish to burn them. Girls have sometimes been burned to death by letting the skirts of their muslin or calico dresses touch the bars of the fire-grate. And sometimes houses are burned down by the window-curtains or bed-hangings catching fire.

LESSON 130.—ON BODIES ABSORBENT OR IMPERVIOUS.

I. Absorbency:

Idea and Name.—Drop some water on the slice of bread. Children will see that the whole has been sucked up into the substance of the bread. Now drop some on the sponge and the brick. Both have sucked up the water. The water is said to be absorbed by the bread and the sponge and the brick; and because the substances will suck up the water they are said to be *absorbent.* Paper, calico, and flannel will suck up water, and so they are said to be *absorbent,* to posses the quality of *absorbency.*

Squeeze the sponge and the bread; children see that some of the water which they sucked up runs out again, but the objects are wet. The brick cannot be squeezed, so all the water must remain in it.

II. Imperviousness:

1. *Idea.*—Previous to the lesson put some water into a thin piece of india-rubber and tie it up. Tell the children when and how you did it. Children will see that the water has remained where you put it. Call attention to the state of the outside of the bag. It is quite dry, showing that none of the water has passed through the india-rubber. Children will thus see that the *india-rubber will not allow the water to pass through its substance.*

Pour some water on a piece of gutta-percha. Children will see that it stands on its surface, it will not pass through the substance. Do the same with a glass vessel.

2. *Name.*—Because the water cannot pass through the substance of the india-rubber, the gutta-percha, or the glass they are said to be waterproof, or *impervious* or *impermeable to water,* to possess the quality of *imperviousness.*

Get or give examples of other substances which are impervious to water, as slate, iron, copper, and indeed all the metals. All these substances are spoken of as *impermeable.*

LESSON 131.—ON BODIES TRANSPARENT, TRANSLUCENT, OR OPAQUE.

I. Ideas:

1. Place on the table a clear glass filled with water, and a sheet of glass; put them in such a position that they stand between the class and the window.

Now place an object behind the glass, and one in the water. Children to say what has been placed, and why they are able to name them. Because the objects can be seen as distinctly as if they were not either behind the glass or in the water. Tell why this is the case. A large portion of the light from the window passes through the water and through the glass. Both the water and the glass transmit the light.

2. By the side of the other objects place a bottle filled with pure olive-oil and a glassful of vinegar. In these liquids put an object. Question as to whether the children can see the objects in the oil and vinegar as clearly as those in the water and behind the glass. No. The objects can be seen, but not very clearly. The reason why they cannot be seen as clearly is because only a small amount of light passes through these liquids. They do not readily transmit the light.

3. In the same position in respect to the window and the class place a thin piece of glue, a thin piece of horn, and a sheet of thick paper. Behind these put some objects. Children to tell what they are. They cannot. Why? Because the objects themselves cannot be seen, only their shadows. The reason for this is because the glue, the horn, and the paper will allow only a very small amount of light to pass through them.

4. In the same position in respect to the window and the class place a piece of slate, a piece of wood, and a bottle of ink. Behind each of these put an object. Children to tell what the objects are. They cannot. Why? Because the objects cannot be seen at all. The reason why this is so is because the wood, the slate, and the ink will not allow *any* light to pass through them.

II. Names:

1. Give the proper names for the qualities which have been discovered.

Because the light will pass through the water and the glass, and enable you to see through them, and so tell what was placed in or behind them, they are said to be *transparent*, to have the quality of *transparency*.

2. Because only a portion of the light will pass through the oil and the vinegar, so that the objects placed behind them can only partially be seen, they are said to be *semi-transparent*.

3. Because the glue, the horn, and the thick white paper allow very little light to pass through them, so that only the shadow of the objects can be seen, and not the objects themselves, they are said to be *translucent*, to have the quality of *translucency*.

4. Because the wood and the slate will not allow any light to pass through, and so when anything is put behind them they cannot be seen at all, they are said to be *opaque*, to have the quality of *opacity*.

5. Other substances beside those which have been observed have the same qualities. Thus rock-crystal is *transparent;* and so is the air. Some kinds of beer are *semi-transparent;* and so is wine. A raw egg, camphor, and thick ice are *translucent*. Gold, iron, and all the metals, stones, and woods, are *opaque*.

It is the transparency of glass, rock-crystal, and of air which makes those substances so useful.

LESSON 132.—ON THE IDEAS OF DULL, BRIGHT, SPARKLING, AND REFLECTIVE.

I. Dull and Bright:

1. *Ideas.*—Put a piece of black paper and a lump of dry clay side by side, and place them in the light. By the side of the other substances put a piece of polished wood and a piece of glass. These also to be placed in the light.

Children to look at the objects and say what they notice in their appearance. The polished wood and the glass appear to shine. The paper and the clay do not shine.

This difference in the appearance of the objects when placed in the light receives a name.

2. *Names.*—Because the surfaces of the polished wood and glass appear to shine they are said to be *bright,* and because the surfaces of the black paper and the clay do not appear to shine they are said to be *dull.*

Children to observe the other substances on the table and say which are bright and which are dull. Yes. The water, the plate of tin, and the stick of sealing-wax are *bright;* the unpolished wood, the slate, and the brown leather are *dull.* The former have the quality of brightness, the latter of dulness.

II. Sparkling and Reflective:

1. *Ideas.*—Next put a lump of loaf-sugar by the side of a lump of chalk, and place them in the light. In what are they alike? Both are *white.* In what way do they differ? In appearance. How? One is *dull,* and the other is *bright.*

Now compare the brightness of the sugar with that of a piece of tin. What do they observe? The sugar has a number of little shiny spots on its surface, and all these spots sparkle. While the entire surface of the tin is the same, it has no spots which sparkle.

2. *Names.*—This particular appearance of the sugar receives a name. It is said to be *sparkling.*

(1) Let the children now look at a lump of salt, and compare its appearance with that of the sugar. It is the same. It is also sparkling.

(2) Now place the lump of clay and the piece of polished tin

behind the flame of the candle, and move them from side to side. Children notice what they do to the light. The polished tin throws back the light of the candle, and it can be seen on the dark part of the wall. The clay does not do this. This throwing back of the light receives a name; it is called the *reflection of the light,* and the surface of the tin, because it will do this, is said to *reflect.*

(3) Children now to notice as the light is passed in front of the looking-glass what takes place. The glass throws the light back again; and so does the polished brass. Next pass the brown leather and the black paper behind the flame. Do they reflect the light? No.

Thus the children will see that the dull surfaces are not reflective, while the polished surfaces are.

(4) In the next place take all the substances which have polished surfaces and place them behind the candle. Children to say whether all have the same power to reflect the light. No. The more highly the surfaces are polished the greater the amount—or the *degree,* as we say—of *reflection.*

3. *Use of the Quality.*—This quality of polished surfaces is very useful. Because of this polished metal and silvered glass are put behind the flame of a candle or lamp so that the light may be reflected and be seen at a greater distance than it would be otherwise. These plates of polished metal or glass are called *reflectors.* They are sometimes put behind the lamps in lighthouses, carriage-lamps, &c.

By and by the children will learn more about the subject of the reflection of light, and then they will be able to understand why it is that by the means of reflectors it is possible to throw the sunlight or the daylight into places which otherwise would never have any. But for the present they must be content with what they have just learnt of the subject, namely, that polished surfaces have the power of reflecting light, and that the amount of light reflected from very highly polished surfaces is greater than from surfaces less highly polished. Another application of this quality of polished surfaces is the manufacture of mirrors or looking-glasses.

LESSON 133.—ON ODOURS.

The objects required for this lesson are a number of substances with and without odour.

I. Odorous and Inodorous:

1. *Ideas.*—Place on the table a number of different substances.

Let a child come to the table, put each of the objects separately to his nose, and then say what difference he finds in them by the sense of smell. He may place all the objects together which he thinks are alike in this respect.

Call attention to what he has done. He has placed the chalk, the flint, the paper, and the salt in one group, and the spice, the camphor, the paint, and the turpentine in another.

2. *Names.*—Now give a name to express the difference which has been discovered in the substances. Because the chalk and all the substances placed with it have no smell they are said to be *inodorous*, and because the spice and all the substances placed with it have a smell they are said to be *odorous.*

II. Different Kinds of Odour:

1. The inodorous substances to be removed, and a child required to smell the others, and place them into two groups according to the character of their odours.

2. The boy will most probably put the tar and the paint together as one group, and the spice, the camphor, and the rose together as another group. Question why he did so. Because the odour of the former is nasty and that of the latter nice.

3. Supply the terms. *Pleasant* and *unpleasant.*

What, then, have they learnt about *the odour of a substance?* It may be *unpleasant* or it may be *pleasant.*

4. The substances which have an unpleasant odour now to be taken away, and a child to smell those which have a pleasant odour, and find out whether there is any difference in the odour, and place together those which have the same kind.

He will probably place the rose and the bottles of scents together, because they have the same kind of odour. Call attention to the fact that he has placed the spices and the camphor together, and he is right. They all have the same kind of odour, and it is very different to the odour of the rose or the scents.

5. Now give a name for these particular kinds of odour.

The pleasant sweet smell of the rose and of the scents is called a *fragrant odour*, and the sweet spicy smell of the cinnamon and other spices is called an *aromatic odour.*

6. The same child now to smell the ground pepper and the wet mustard, and compare the odour of these with the other kinds of odours. He must smell them very gently. A very gentle sniff is enough to make the eyes water. The odour is *hot and biting.* Tell that this particular sharp biting smell is called a *pungent odour.*

LESSON 134.—DIFFERENT KINDS OF FLAVOURS.

I. Tasteless, Insipid, and Sapid:

1. *Ideas.*—Let a child taste some water and say what kind of flavour it has. Next let him taste the white of a raw egg, then some flour, and say what he observes as to the flavour of each. They have a very little flavour, and so they differ in that respect from the water.

Blindfold a child, then put some sugar into his mouth. Ask him what you have done, and why he knows it was sugar. By its flavour. Do the same with salt and vinegar. How is it that he is able to say what particular substance was put into his mouth though he did not see it? Because each has a very decided flavour.

Now let the boy arrange all the substances into groups according to what he has discovered respecting them by the sense of taste. The class will see that he has formed *three:* one for the water, which has no flavour at all; one for the white of the egg and the flour, which have no decided flavour; and one for the sugar, salt, and vinegar, which have a very decided flavour.

2. *Names.*—Give proper names for the three ideas thus gained:

Because water has no taste or flavour at all it is said to be *tasteless.*

Because the white of an egg and the flour have not a decided taste or flavour they are said to be *insipid.*

Because the sugar, the salt, and the vinegar have a very decided taste they are said to be *sapid.*

II. Different Kinds of Savours:

Ideas and Names.—Put away the tasteless and insipid substances, and notice particularly the sapid ones, so as to distinguish one from another.

A boy to come and do what he is bidden, and then tell the class what he has found out respecting the tastes or flavours of the different sapid substances.

1. First compare the flavour of the salt with that of all the other sapid substances. It is very different. It has a flavour of its own, and this particular taste is called *saline.*

2. Next try the sugar; its flavour is different. Now taste this honey; its flavour is like that of the sugar. This particular taste is called *sweet,* or more properly *saccharine.* You will remember, I dare say, that ripe fruit has this flavour. Most children are fond of anything which is sweet.

3. In the next place compare the taste of the vinegar with that of the sugar. You will, I daresay, remember that unripe gooseberries and other fruits have the same kind of flavour. This particular taste or flavour is called *sour* or *acid*. The word *tart* is also used to express this kind of flavour. Some children are fond of sour things. But they must bear in mind that unripe sour fruit is not wholesome, and should not be eaten raw.

4. Hops and chamomiles next to be tasted. The boy will show by his countenance that he does not like the flavour. He will probably say they are nasty. This particular flavour is called *bitter*.

5. Let a child put a small portion of dry mustard on the tip of his tongue, then rub his tongue against the roof of his mouth. The class to look at the boy's face while he does this. Question as to what the boy has found out respecting the flavour of the mustard. It is *hot and biting*.

Next let the boy taste the pepper. Its flavour is something like that of the mustard.

Tell children that this hot biting flavour of the mustard and pepper is called a *pungent flavour*.

6. Show a piece of alum. A child to put a very small portion into his mouth and tell the class what it does to his tongue and mouth. It draws or contracts the flesh.

Tell that instead of saying the alum draws the flesh, we say it *contracts* or *binds*, and that particular flavour and its effect are called *astringent*. Oak bark and the medicine called *quinine* have the same effect on the mouth, and so they are also said to be *astringent*.

III. How Insipid Substances can be rendered Savoury.—Next notice some of those substances which have no decided flavour, or are *insipid*. Mutton broth, for example. Have it tasted. Put a small quantity of salt in and stir it up. Children taste it again and say what difference they observe. It is much more pleasant to the taste. It is now said to be *savoury*. It is the salt which has made the difference.

Children must remember that an insipid substance can be made savoury by the use of a small portion of salt. This is one reason why salt is eaten with broth, potatoes, and many other kinds of food which in themselves are insipid.

SECTION II.—THE FORCES OF NATURE.

Lesson 135.—ON THE IDEAS OF REST, MOTION, AND FORCE.

First—Rest and Motion.

Ideas:

1. Call out three boys; let one sit in a chair at the end of the room, the others when bidden to walk up and down the room. The class to say what they observe respecting the boys and the table by the side of which the other boy is sitting. Thus work out that—The boy who is sitting has not changed his position. He was placed by the side of the table, and there he has remained. The other boys were also placed by the side of the table, but now they are at the end of the room—they have changed their positions.

While the boys are walking, and so changing their places, they are said to be *in motion*. What, then, is motion? Yes: *motion is a change of place*. The boy who is sitting, and has not changed his place, is said to be *at rest*.

2. Let the boys who were told to walk up and down the room do so again. Each to start when told. Call one A, and the other B. A to walk and keep time with the teacher's pointer, taking one step at each beat. B to keep time to the assistant's pointer, taking one step at each beat. The beats of master and assistant to be in different time.

3. Call attention to what takes place. Class will see that A has walked all round the room in the same time as B has taken to walk half round. What, then, can they say of A's walking when compared with B's. It was faster, and so he passed over more ground in the same time.

Tell that the difference in the time of the walking is called *the rate* or *velocity of the motion.*

4. Question as to the exact velocity of A's motion. Cannot tell: all they can say is that it was greater than B's. So if they want to ascertain the velocity they must take into consideration the time occupied in walking the distance.

Make this clear by further illustrations:

(1) Suppose A to set off on a walk along a country road. He walks on and on for an hour without stopping. At the end of the hour he finds himself exactly four miles distant from the starting place; and at the end of the second hour he is eight miles from it. In this case

we should say that A is walking at the rate or with the velocity of *four miles an hour.*

(2) Again: a few days ago a person was travelling by rail, and as the train was going at a great speed he was curious to know at what rate it was going, so he took out his watch and marked the exact time which elapsed while the train ran from one mile-post to another. He found that the distance was done in one minute and thirty seconds, that is in ninety seconds. Then he said there are three thousand six hundred seconds in an hour, and so if I divide 3600 by 90 I shall find at how many miles an hour we are travelling. Let the class work the sum: $3600 \div 90 = 40$. So you see the train was travelling at the rate or velocity of forty miles an hour. At the time he made this calculation he was thirty miles from London, so he said, If the train continues to travel at the same speed I shall be in London in forty-five minutes.

Second—FORCE.

Idea.—Shortly after this the train moved at a slower rate, or slackened speed, and gradually came to a stand. It came to rest. How was this? Yes; the engine-driver turned off the steam, and the guards applied the brakes to the wheels. Thus children will see that it required *force to stop the motion of the train.* When once the train came to a stand, or was brought to a state of rest, it did not move again until the engine-driver turned on the steam, and so applied force.

Thus, then, they must remember that *force* acts both in setting a body in motion when it is at rest, and in bringing to rest a body which is in motion. In other words, *That which changes the state of a body is called* FORCE, *whether that state be one of rest or of motion.*

Place a cricket ball on the table. It is in a state of rest. But suppose a game was being played, the ball would be thrown by the bowler. Question as to who would be able to throw the ball with the most force. The boy who had the strongest arms. Here force has set the ball in motion. Suppose a ball thus set in motion with great force to have to be stopped. It will require considerable force to do so. Provide two balls, one small and light, the other large and heavy. Require a child to set both in motion, and say what difference he observes in the amount of force required to do so. The large and heavy ball requires more force than the small one. Why is this? The one has a greater mass to be moved, and requires greater force to overcome the resistance of this mass or *inertia,* as it is called.

Thus, then, the children will learn that, *The greater the force which has been exerted to set anything in motion, the greater will be the force necessary to bring the thing to a state of rest;* and the greater the mass or inertia of a body the greater the force required to set it in motion.

Friction.—Tell the class that there is another point respecting force which they must learn, but which cannot well be made the subject of experiment in the school-room. They must think about their winter amusements of sliding and skating. Take up the sliding, and question thus: Did you go along quicker or slower on the slide than on the other part of the ice? Quicker. Why was this? It was smoother. Yes; and if you tried to slide on the rough ice you found that it stopped your motion: the rougher the ice the more difficult it was for you to go along. The rough ice acted as a force to bring you to rest. This particular force is called *friction.* The smooth part of the ice which you called the slide offered less resistance or exerted less force because there was less friction.

Refer to the difficulty we experience when we attempt to walk on smooth ice. Suppose our hills were as smooth as ice, what would be the result? No one would be able to ascend them, for as one step was taken upward, the foot would slip down again. Thus, then, we see that without the force of friction we should fare very badly in the matter of travelling on foot.

Still it is very useful to be able to reduce the amount of this force, in order that we may be able the more easily to set bodies in motion, and to increase the velocity of this motion. It is on this principle that railways are constructed. The smooth iron wheels of the carriages run easily on the smooth steel rails, and thus it takes less force to set the train in motion than it otherwise would, and the velocity of the motion is greater: the force exerted by one locomotive-engine is sufficient to draw as much as 300 tons, and this at a speed of twenty miles an hour or even more.

Lesson 136.—GRAVITATION.

I. Idea:

1. Question the children on what they have noticed when they threw a ball into the air. It went up a certain height, less or more, according to the force with which it was thrown. After ascending this height the ball seemed to remain still for a moment and then

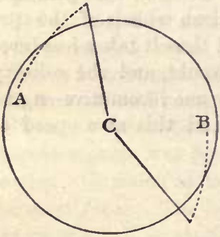
descended to the earth again. At last it came to a state of rest on the surface of the earth.

Many boys have seen sky-rockets let off, and they have noticed that they ascended very high in the air, and then after they were burnt out the cases with the sticks to which they were fastened descended, and, like the ball, came to a state of rest on the surface of the earth.

Question as to the exact mode in which the objects fell. They did not return to the spot from which they were thrown, but descended to the earth in a straight line from the point at which they stopped in their upward progress.

Now the empty cases and their sticks descended to the earth for the same reason that the ball fell to the earth again. Why did they fall? Because they were heavier than the air, you say? This is not exactly the reason. Why then? We must try and find the reason.

2. Question the class as to the shape of the earth. A sphere. Show a small globe, hold it up, and put the end of a pointer on the spot occupied by England. A boy to find out what country is directly on the opposite side. New Zealand. Let the children suppose they were living there. When they stood up their heads would be placed in an opposite direction in respect to the sky to what they are now. When, therefore, they threw a ball towards the sky—or, as they would say, up—it would, in point of fact, be thrown downwards or into space. And yet, when the ball was thrown, it would after a while descend to the earth again, and in the same manner as it does in England. And the same would happen if the ball was thrown into the air at the equator, or in any other part of the world. Now, if the weight of the ball made it return to the earth in England, the same quality ought to make the ball in New Zealand fall further from the earth.



C, *Centre of Earth.* A, B, *Points from which the body is thrown: dotted lines the direction of the upward passage, black lines the direction of the fall.*

The children will thus see that the fact of the ball being heavier than the air does not account for the fact that when thrown up it descends to the earth again.

II. Name.—Then why does the ball when thrown up fall to the earth again? They do not know, so must be told.

The ball when thrown up returns to the earth again because it is drawn or attracted to it by a force which belongs to the earth. This particular force is called *gravitation.*

This force seems to reside in the centre of the earth, because every falling body descends in a line which is perpendicular to the centre. The diagram on page 342 will make this clear.

Gravitation acts at a distance, and at any distance. More will be learnt of this wonderful force when the children study Physical Geography.

III. Use of Gravitation.—This wonderful force is of great use. Let us suppose the earth did not draw all things to itself. In that case were a boy to jump off a hill he might never come down again, but keep floating in the air; and this would not be very pleasant.

Again, if there were no such force as gravitation, nothing would remain where it was placed, and then we should see tables, chairs, and all such things flying about the world, and, as will be learnt some day, the earth itself would not keep in its place in the heavens.

LESSON 137.—COHESION.

I. Idea.—We must now endeavour to learn something about another force. Show a piece of stone, a bar of iron, and a piece of string. A boy to take a hammer and break them in pieces, that is, he is to separate the particles of which those objects are composed. Commence with the iron. Can he do this? No. Next take the piece of string and try to separate its particles by pulling: they also hold together. Now take the piece of chalk and strike it. After a few blows its particles are separated from each other; but still they hold together. What is true of the chalk is true also of the stone, the iron, and the string. Here, then, is another force. What is it? A force which binds together the particles of which the body is composed, and which cannot be overcome without the exercise of another force.

II. Name.—Tell that we have a name for the force which thus binds together the particles of which a body is composed. It is called the force of *cohesion*.

1. Now lead the children to see how this particular force acts. Show a piece of coarse sandstone. It is made up of grains. Separate its particles. Children will see that you have considerable trouble to overcome the force of cohesion. Now that the particles are all separated a boy to endeavour to restore the lumps by putting all the particles together again. What must he do? Exert force. Let him

try. But although he is exerting force he has not done what he wished. Question as to why he has failed? They do not know. Enable them to see how it is by another experiment. Provide two pieces of plate-glass. Children to observe their surfaces. Very smooth and highly polished. Now place them on each other and press them slightly. A boy to try to separate them again. He cannot. They seem bound together. Now, if they examine the two pieces of glass they will find that they are very close together—one plate adheres to the other.

2. Have two other pieces of glass whose surfaces are not as smooth. Place them on each other. Children will see that their surfaces do not come so near each other as in the case of the former pieces. Let a child try to remove them. He can. They are not bound together. What, then, make the former pieces hold together? *Their particles are in actual contact,* and when this is the case the force of cohesion acts.

3. It is important to bear this in mind, especially when we have to do with plates of smooth glass. It has sometimes happened that very large pieces of plate glass have been spoiled by being placed one on the top of the other without anything between them, when they were held so firmly by the force of cohesion that they could not be separated.

III. How the Force acts.—Thus, then, they learn that the force of cohesion acts differently to the force of gravitation: the former only acts *when the particles of matter are in actual contact;* the latter acts *when the particles are at a distance.*

IV. Use of the Force.—Now suppose there was no such force as cohesion. What would be the result? It would be impossible to use any substance, for everything would when touched fall into powder, and this would be very inconvenient.

V. Degree of the Force in Different States of Matter.—What they have learnt respecting cohesion applies to solids: but they know that there are two other states of matter, namely, liquids and gases. It is necessary that they should understand how the force of cohesion acts in these.

Have some water, a pint, in one piece, so to speak. Tell children that you want it divided into smaller portions. A boy to do this. Give him a small cup and some small glasses. Call attention of the class to what the boy is doing. Taking some of the water out of the larger vessel with the cup and putting it into one of the smaller. Ask the boy whether he has much difficulty in dividing the water into smaller portions. Does it require much force on his part to do what he is doing? No. Now, why is this? Because the particles of which the water is formed are not bound together very firmly. Do the same with some milk and some oil. What, then, do they learn from this? That *cohesion acts less powerfully in liquids than in solids.* That the force does act in some degree in liquids may be shown by pouring out a small quantity of quicksilver on a smooth surface, when it will assume a spherical form, as will also the portions into which the globule may be divided. Dewdrops on leaves and flowers are formed by the action of the same force.

Tell the class that in the case of gases you cannot lead them to *see* how the force of cohesion acts; but that they may understand how it is by studying again the lesson on GASES. If they think of the quickness with which the gas in any part of the house goes out after it has been turned off at the meter, they will readily understand that the gas-pipes could not have been packed full of gas in the same way that a water-pipe can be filled with water. They were taught in a former lesson that the particles of a gas seek to get as far away from each other as possible; or, as it is said, they *repel each other.* Now, as this is the case, the *Force of Cohesion does not act at all in the substances known as gases.*

LESSON 138.—CHEMICAL ATTRACTION.

I. Idea:

1. Provide a jar of oxygen gas and a piece of charcoal. Make the charcoal red hot, and suspend it in the gas. Call attention to what takes place. The charcoal burns very brightly, and is soon consumed.

2. Question as to whether the jar is empty or not. Tell that if the jar is empty when you remove the stopper, the air will rush in and fill it; and if it is full of air, a lighted candle will continue to burn when placed in the jar. Place the lighted candle in the jar, when the children will see that as soon as it is placed there the flame is extinguished. If the jar had been empty the air would have filled it, and the flame would not have been extinguished.

3. The children will see that not only is the jar not empty, but that it is filled with another gas, which will not allow the candle to burn.

Explain this to the children. The jar is now filled not with oxygen, but with a gas called *carbonic acid*, or, more properly, *carbon dioxide.* Question as to how it got there, and then explain it fully.

4. The jar was at first filled with oxygen gas: then a piece of red-hot charcoal was put into the jar. Charcoal is composed of a substance called *carbon.* The carbon burnt very brightly in the presence of the oxygen; and this was because the oxygen had a liking for the carbon, and rushed as it were to it, and the two separate substances became united and produced another substance—a gas altogether different to that with which the jar was at first filled; so that instead of the oxygen and the carbon being there as separate substances, we have a combination of the two, forming a new gas, called *carbon dioxide,* or more commonly, *carbonic acid gas.*

II. Name.—This rushing together of the oxygen and the carbon is caused by *chemical force* or *attraction.* It is sometimes called *chemical affinity.* You learn then that *chemical attraction is a force which acts between two different kinds of bodies, and by its action produces a substance quite different to either.*

III. Use of the Force.—This force is of great value to us. Without it, it would be impossible to make a fire; for it is the liking which coal has for oxygen that keeps it in an active state. The greater the amount of oxygen which is allowed to enter a fire, the greater will be the energy of the fire; and if the supply of oxygen is entirely cut off, the fire will be extinguished. Children should always keep this fact in mind. Without the aid of this force it would be impossible to make many of those useful substances which we need in our daily life. Soap, for instance, is an example.

Lesson 139.—MAGNETIC ATTRACTION.

I. Idea.—Procure a small bar magnet and some iron filings. Hold one end of the magnet over the filings. Children to say what takes place. The particles of iron are drawn by the magnet towards itself. Each particle of iron holds on to another particle, and the whole are held by the magnet.

II. Name.—Tell the children that this power which the magnet has of drawing the particles of iron to itself, and holding them, is called *magnetic attraction.*

III. Where the Power Resides.—Clear the magnet of the iron, and, holding the bar in a horizontal position, sprinkle some filings on it. Children to say exactly what they observe.

1. The filings are collected in the greatest quantity at the two extremities of the bar.

2. There is a space in the middle of the bar to which no particles of iron are attracted.

Magnet dipped in Filings.

Tell the children that these two spots round which the particles cluster are called *the poles of the magnet.* One is spoken of as the *north pole*, and the other, or opposite one, as the *south pole.* Thus, then, they learn that a magnet has two centres of magnetic force, each having an equal power of attracting iron.

IV. Transmission of the Force:

1. Place a thin sewing needle on a piece of cardboard; hold the magnet above it, the children saying what they observe:

(1) There is a portion of air between the magnet and the needle.

(2) The force of the attraction of the magnet is powerful enough to draw the needle to itself.

What, then, can they conclude?—*Magnetic attraction is transmitted through the air.*

2. Interpose a thin piece of wood between the needle and the magnet. Move the magnet backwards and forwards, children saying what takes place. The needle follows the magnet. Why is this? Because the magnet attracts the needle. What, then, can they say respecting the force in this case? *Magnetic attraction is transmitted through a solid substance.*

3. Place the needle in a glass of water: hold the magnet against the side of the glass, and move the magnet. Call attention to what takes place. The needle follows the magnet. How is this? It is attracted by the magnet. What is there between the magnet and the needle? The substance of the glass, and the water. What, then, can they say of the force in this case? *Magnetic attraction is transmitted through a liquid.*

4. Place the needle on the piece of cardboard; put the magnet under, first close to the card, and then at a little distance from it. Children say what they observe. The force of the magnet is greatest when nearest the needle, less so when at some distance from the needle, and it has no power over the needle at a great distance. What, then, can they say of the force? *The attractive force of the magnet decreases with the distance at which it stands.*

LESSON 140.—ELECTRIC ATTRACTION.

I. Idea.—Provide a sheet of brown paper, a few pieces of very thin tissue paper, or a few downy feathers, or even a pinch of saw-dust. Be sure that all are very dry. Get a stick of sealing-wax or a glass rod.

Warm the glass and rub it briskly with a piece of silk.—If you use sealing-wax, rub it with a piece of woollen cloth.—After having rubbed the glass for a few seconds, hold it immediately over the saw-dust or feathers, calling the attention of the class to what you have done and what takes place. As soon as the rod is held over the feathers or paper they jump up to the rod, and are held there. What, then, can they say the rod has done to the feathers? Attracted them.

II. Name.—Tell the children that by rubbing the glass rod with the silk the former had a force produced in it called *electricity*, and one of the properties of which is, as they see, that of attracting to the body so charged other bodies which may come near it. This kind of attraction is called *electric attraction*.

III. When Present.—After having rubbed the hand along the rod to take from it whatever electricity may be left, hold it over the feathers again. The children will see that the feathers are not attracted. Question as to what must be done to give the rod the power. Rub it again. Do it and repeat the experiment. The children will thus see that in order to charge the glass with electricity it must be *excited*. They will thus learn that, *electric attraction is present only when the body which possesses it is excited.*

Note.—Lessons 139 and 140 may be treated as one.

LESSON 141.—CAPILLARY ATTRACTION.

I. Idea:

1. If possible get two or three very small glass tubes of different sized bores, open at both ends—the stems of broken thermometers will do—and some lamp cottons. Colour some water blue or red—stone blue will do very well. Put the water in a tumbler. In this water insert one end of the tubes, and require the children to observe what takes place.

(1) The water rises in the tubes.

(2) The water in the tubes stands at different heights.

(3) The water stands at the greatest height in the tube which has the smallest bore.

2. Now take the lamp cottons. If the children have had the lesson on POROSITY, refer back to it. Place one end of the cotton in the coloured water. Call attention to what takes place. The water gradually ascends until at last it rises to the top of the wick.

3. Put a small quantity of the coloured water into a saucer, and in the water place a large piece of dry salt. Children to observe what is the result:

(1) The water rises through the pores in the salt, which, being very small, communicate with each other from a number of minute tubes, up which the water rises.

(2) The whole substance of the salt is at last filled with water, the top portion being as wet as the bottom.

II. Name.—Question as to what they have observed in each case. The water has been drawn up through the small tubes which exist in the bodies themselves, without any force being applied either to the water or the materials. The power resides in the tubes themselves to attract the liquid. Tell the children that this particular force is called *capillary attraction*.

III. Examples of the Force:

1. It is the action of this force which enables us to burn oil and melted tallow in lamps and candles. The melted materials rising in the wicks supply the flame with fuel.

2. If bricks are placed on wet soil the water rises through the pores in the bricks, and passes from brick to brick, so that in time the whole wall will be damp. To prevent this the lower courses of bricks should be separated from the higher by a layer of non-porous substance, such as the best kind of slate.

3. A small quantity of water spilt on a table-cloth will spread.

4. If only a small portion of a cloth be left in the water, the whole cloth will in the course of time get wet.

IV. The Force only acts when the Liquid wets.—Into some quicksilver insert the open end of a dry tube of glass. Children will see that the fluid does not rise in the tube, as is the case with water.

Pour out a little water in one saucer, and a small portion of quicksilver into another. Run both off into other saucers. Children state what is the difference in the state of the saucers from which you poured the two liquids—one is wet, the other is not.

What, then, has the water done which the quicksilver has not?

wetted the surface of the vessel into which it was put. Quicksilver does not wet.

Tell the children that this is the reason why the force of capillary attraction does not act in the case of quicksilver. *The force only acts when the liquid wets.*

SECTION III.—THE ELEMENTS OF PHYSICS.

LESSON 142.—THE ATMOSPHERE.

I. Introduction.—Tell children the subject of the lesson, and by a few questions on the continuous action of breathing, and where they are able to breathe, work out that: air is everywhere diffused, and is necessary to sustain life. Tell that what is true of themselves in this respect is true of all animals and plants.

II. Physical Properties:

1. *Transparent.*—By reference to the fact that air is everywhere present, and yet cannot be observed by the eye, children conclude that it is *invisible*, and of course *transparent*.

(1) Direct attention to the colour of the sky on a clear day. Blue. When they look up to the sky, at what are they really looking? The whole mass of the atmosphere above them. When they look across the room or street, or downward when on a hill, at how much of the atmosphere are they looking? Only a small portion. Thus, then, they will learn that *when viewed in great masses the atmosphere appears blue.*

(2) Explain the cause of this. The higher we ascend the thinner the air becomes: thin air absorbs less light than dense air, so that the higher we go the deeper will be the blue, and at last it would be black. If it were not for the blue colour of the atmosphere the sky would be quite black, and the stars would shine out in broad daylight.

2. *A Substance.*—By experiment lead the children to see that, though invisible, the air is yet a substance. Put some water in a glass vessel, and in the water place an inverted tumbler. The water does not fill the tumbler. Why? There is something in the glass already. This something air. (Refer back to the lesson on IMPENETRABILITY.)

Though the sense of sight cannot recognize air, the sense of touch can. When the air is put in motion the resistance is sensible to our hands and face.

When the whole mass of air is in motion it is called *wind.*

3. *Compressible and Elastic:*

(1) Develop these qualities by experiment.

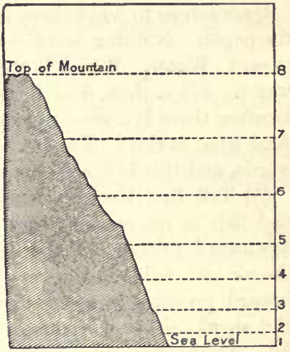
a. Invert a tumbler in a vessel of water. Children observe what takes place. Water does not fill the glass. Why? Because it is already filled with air, which is a substance: but the water does go up a short distance, and so must have pressed the air in the glass into a smaller space. (See lesson on GASES.) Hence air is *compressible.*

b. Partially fill a bladder with air, and secure entrance by tying it very tightly. Hold the bladder in front of a fire, or at some distance over a spirit-lamp. The air will expand and the bladder will be full. Cool the bladder; the air contracts and occupies less space. Warm the bladder again, and again the air will fill it.

If the teacher possesses an air-pump, place the partially filled bladder under the receiver; exhaust the air. The air will expand as pressure is taken off, and contract again when air is admitted into the receiver.

(2) Show how these properties tend to make the air near the earth's surface denser than that which is above.

Make the accompanying diagram, and explain. Suppose each layer to be composed of some compressible substance—say wool—each containing the same quantity. Layer 1 would have to bear the weight of the other seven, and would be pressed closer together than 2, which would only have to bear the other six; 3 would be pressed less than 2, and 4 than 5, and so on, and No. 8 would not be pressed at all. (Refer back to lesson on GASES.)



4. *Weight or Pressure:*

(1) Provide a glass tube open at one end only; fill it with a coloured liquid. Place the thumb over the opening and invert the tube, placing the open end in a glass of water. The water in the tube will not fall out. Why? The weight or pressure of the air on the surface of the water in the glass is more than the weight or pressure of the water in the tube, and so keeps it in its place. Tell the

amount of pressure: *15 lbs. to every square inch of surface at sea-level.*

(2) The great pressure of the air can be shown by the following experiment:—Procure a very thin tin vessel, with a hole in the top for a cork. Put a small quantity of water in the vessel, boil it, and when the vessel is full of steam cork it up, and rapidly cool it by pouring cold water on it. The cold water will condense the steam, causing a partial vacuum to be formed in the vessel, the sides of which not being able to resist the pressure of the air will collapse.

(3) Tell the children that the pressure on the body of an average-sized man is about 15 tons, or 33,600 lbs., and yet he is not crushed. Lead them to see why.

(4) Fill a tumbler with water. Place over it a very small sheet of smooth writing-paper. Put the palm of the left hand on the paper, and with the right hand invert the glass, holding it by the sides. Withdraw the left hand. The water will not fall out. Why?

Call attention to the state of the sheet of paper. It adheres to the glass, and its surface is not level, but is rounded inwards.

Question as to what there is between the floor and the one side of the paper. Nothing but the air. What is on the other side of the paper? Water. Which is the heavier, the water or the paper? The water. Why, then, does it not force the paper away and fall out? Because there is a greater weight or force pressing on the other side. And what is this? The air. Which way is it exerting force? Upwards, and this is the reason why the water cannot fall out.

(5) Tell that the *air presses in every direction with the same force*, and this is the reason why the human body is not crushed by the downward pressure of the atmosphere. The air in the lungs and the air and fluids in the vessels are pressing on all sides, and as the inward pressure is equal to the outward pressure neither is felt. But should either be reduced or increased the effect would be painful. Thus when men descend beneath the surface of the water in diving-bells, and the air is forced into the bell, they feel an unpleasant sensation in the ears, &c.; and when men ascend very high mountains, or in a balloon, the outward pressure being less, the air and fluids within the body exert their force, and a painful sensation is experienced.

III. Chemical Properties:

1. *Constituents.*—Provide a bell-glass—a large empty pickle-glass will do. Set light to a piece of candle and stand it on a plate, or better still a flat piece of glass. Cover the candle with the glass, and call attention to what takes place.

The surface of the glass is covered with moisture. After a short time the candle burns somewhat dimly; the dimness increases, and at last the flame is extinguished.

The children may think that the candle has gone out because the whole of the air has been consumed, and that the jar is empty.

To prove that this is not the case question thus: If the glass is empty when the plate is removed what will the air from the outside do? Flow in and fill it.

If this be done and the jar be filled with air, what will the air allow the candle to do? Burn with a flame as that does now which is placed on the table.

Slip away the plate carefully and put the burning candle into the jar. What has taken place? The flame has been extinguished in a moment.

What does this prove as to the condition of the jar? It was not emptied by the first burning candle.

And something more? It is now filled with what will not allow the candle to burn.

And something more? That there is a certain amount of watery vapour in the jar.

From this the children will be able to conclude that—

(1) The burning of the candle took something out of the air; and,

(2) Added something to what it left behind.

Tell the fact that the air is essentially a mixture of oxygen and nitrogen gases, its average composition by volume being—nitrogen, 78·49, oxygen, 20·63.

The oxygen was required for the combustion of the candle, and so was used up. The nitrogen was not needed, and so remained unaltered.

In the combustion two products were formed.

The fatty matter of the candle contains hydrogen; a portion of this united with a portion of the oxygen and formed *watery vapour*.

The fatty matter of the candle also contains carbon; a portion of this united with a portion of the oxygen and formed *carbonic acid*, or *carbon dioxide* as it is called.

Thus, then, the children will see that after the candle went out the jar was filled with nitrogen and carbonic acid gases, and watery vapour. Now as neither of these gases will support combustion, when the second candle was introduced the flame was at once extinguished.

2. *Uses or Properties.*—By working out the above points the children will learn what are the constituents of air, and one of its chemical properties, namely, *supporting combustion*.

As the children know that man, animals, and plants require air to keep them alive, they will at once give the second use of the air resulting from its constitution, namely, *to support life.*

Question out how the air is used by man and other animals for this purpose, namely, by respiration, and lead them to see the changes which take place during the operation.

3. *The changes effected by respiration:*

(1) Buy a pennyworth of lime-water—any chemist will sell it to you. Tell the children that it contains a small quantity of lime in solution, and that if carbonic acid gas be mixed with it, the lime will unite with the gas and form a carbonate of lime, and this will render the solution milky.

(2) Take one of the small glass tubes used in the lesson on CAPILLARY ATTRACTION, place it in the lime-water and let a child breathe through it; the class observing and describing what takes place.

(3) After a short time the water becomes milky. What, then, can they conclude? Carbonate of lime is formed. What gas then must have been put in the water? Carbonic acid.

Where did it come from? Yes, from the boy's lungs. Did it come from his lungs simply because he was breathing into the water? No, but by that means it was made evident.

What, then, do they learn respecting the nature of the expired air? It contains carbonic acid gas. The source of this gas is the oxidation of the blood in the lungs. The blood, as supplied by the digested food, contains, among other things, carbon, and this, uniting with some of the oxygen of the inhaled air, forms carbonic acid gas. Somewhat in the same way as it was formed by the combustion of the candle under the bell-glass.

By reference to the constant operation of breathing, and the enormous number of human beings and other animals who are thus using up the oxygen, lead the children to conclude that there must be an enormous quantity of carbonic acid gas discharged into the atmosphere during every minute of time.

(4) By reference to the products of the burning of the candle children will see that the consumption of combustible materials is another source of carbonic acid gas. Give the following interesting fact bearing upon this point:

The French chemist Boussingault has estimated that in Paris the following quantities of carbonic acid are produced in every 24 hours:

By the population and by animals,	11,895,000	cubic feet.
By processes of combustion, . . .	92,101,000	,,
Total,	103,996,000	,,

If that be true of Paris, then the quantity produced in London must be considerably in excess, because the population is much larger, and the number of fires constantly burning greater.

4. *How the balance is maintained.*—Tell the children that notwithstanding this enormous continual production of carbonic acid, the composition of the atmosphere which surrounds the globe does not vary, for plants in the process of their growth decompose the carbonic acid, assimilating the carbon to build up their tissues, and restoring to the atmosphere the oxygen.

Teachers should not fail to impress the children with a sense of the wisdom and benevolence of God in this arrangement.

LESSON 143.—MEANS OF MEASURING THE PRESSURE OF THE ATMOSPHERE.

THE BAROMETER.

The barometer (derived from the Greek words *baros*, weight, *metron*, a measure) is an instrument for measuring the weight of the atmosphere.

I. Parts.—If possible an upright barometer—if not at hand then a diagram of one—to be observed by the children, parts pointed out and names supplied.

1. A glass tube 33 inches long of equal bore all through and closed at one end. A, Fig. 1.

2. A cistern or reservoir attached to the lower end of the tube so constructed that at one part the air can enter. B, Fig. 1.

3. A quantity of quicksilver, some of which stands in the tube forming a column, and some in the cistern. See black line in tube A.

4. A frame into which the tube and cistern are fixed. C, Fig. 1.

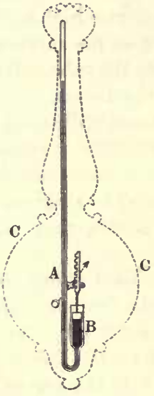


Fig. 1. Wheel Barometer—back view.

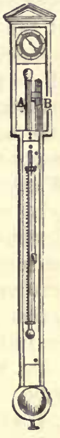


Fig. 2. Upright Barometer.

5. At the upper end of the tube a fixed scale of inches and tenths of inches, commencing at 27 and ending at 31 inches. A, Fig. 2.

6. A movable scale made to slide along the edge of the fixed scale, and so divided that *ten* of its divisions are equal to *eleven* of the smallest divisions of the fixed scale. This is called the *Vernier scale.* So named from Peter Vernier, who invented it in the year 1630. B, Fig. 2.

II. Conditions of its Action.—Refer back to the lesson on the ATMOSPHERE. Air has pressure. This pressure exerted equally in all directions.

1. Children observe the barometer. There is a space between the top of the mercury and the top of the tube. If this was filled with air what would it do to the quicksilver? Press it down.

If this took place what would the quicksilver do? Run out of the tube into the cistern.

But as this is not the case what conclusion may we draw respecting this space? There is no air in the tube above the quicksilver.

This is the case. *The space is void of air—is a vacuum.*

2. In the next place call attention to the cistern. In one part it is open to the atmosphere, the air can enter and touch the surface of the quicksilver. There being no pressure on the top of the column of quicksilver, the pressure on the surface of the quicksilver in the cistern causes it to rise in the tube.

If the pressure on the surface is increased what will it cause? The quicksilver to rise higher in the tube.

If the pressure on the surface is decreased what will be the effect? The quicksilver in the tube will be lowered. The greater the pressure on the surface the higher will the column stand, and the less the pressure the lower it will stand.

What, then, will the varying height of the column show? The varying pressure of the atmosphere.

EXPERIMENTS.—The children may be led to see by either of the following experiments that the air does support the column of quicksilver.

1. Get a tube closed at one end; fill it with quicksilver or water; when full place the forefinger of the left hand over the opening, as in A B, Fig. 3. Invert it into a vessel of mercury or water, as the case may be. Withdraw the finger, place the tube upright, as shown in Fig. 4, where M N is the cup of mercury, the space A C the vacuum. If the tube is 32 inches long, and is filled with quicksilver, the fluid in the tube will fall to about 29 or 30 inches, according to the state of the atmosphere.

2. Take a glass tube open at both ends, fit a cork into it, and fasten a wire to the centre of the cork, which will form a piston to

the tube. Place the piston even with the lower end of the tube, and in that situation place the same end of the tube in the mercury (or water), Fig. 5. Hold the tube, steadily pull up the piston: the mercury will follow the piston, and will fill that part of the tube which is below the piston, Fig. 6. If the tube used is more than 30 inches long, when the piston is raised above that height there will be a space between the bottom of the piston and the top of the column of mercury. The column will be balanced by the weight of the atmosphere; the space will be a vacuum. The whole thing will, in point of fact, be a barometer.

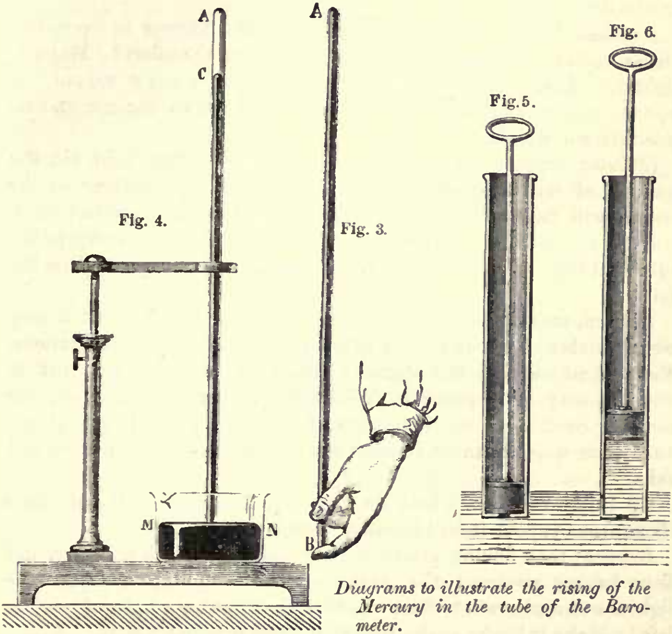


Fig. 4.

Fig. 3.

Fig. 5.

Fig. 6.

Diagrams to illustrate the rising of the Mercury in the tube of the Barometer.

III. Uses of the Barometer:

1. *To determine the Variations in the Pressure of the Atmosphere.*

(1) Lead the children to see that damp air is lighter than dry.

Warm some water over a spirit-lamp. As the water gets hot it passes off in vapour. Call attention to the vapour. It rises in the air.

What does this fact prove as to the relative weight of the vapour and air? That the vapour is lighter.

Keep the water at the boiling point. Much vapour is passing off into the air. Where does it all go? In the air. Yes. The air has received the whole.

Suppose, then, a large quantity of this light vapour to be mixed with a certain portion of dry air, what will be the effect? Make it lighter. Yes. The greater the amount of watery vapour, or *aqueous vapour*, as it is called, the lighter will the air become, and its pressure will decrease.

(2) Now suppose a barometer to be placed in this light air, the amount of the pressure on the surface of the quicksilver in the cistern will be less than it would if the air were dry. What, then, will be the effect of this diminished pressure? The mercury in the tube will fall. Yes. And the lighter the air the greater will be the fall.

If, then, we see the mercury in the barometer is falling, what may we conclude? That the air is getting charged with watery vapour. Yes. And suppose the mercury continues to fall, what sort of weather may be expected? Yes, wet weather. Because the air can only contain a certain quantity of water in the form of vapour, and when it is saturated it must let it fall—in other words, it will rain.

(3) In the next place lead the children to see that as the air loses its aqueous vapour it will increase in weight.

Suppose that having mixed a light substance with a heavy, and thus having rendered the whole relatively lighter, we take the lighter out again, what effect will that have on the weight of what is left? Make it heavy again, restore it to its original weight. Yes.

If, then, the air parts with its watery vapour, what will be the effect of this on the air? It will be again heavier.

Now if a barometer be placed in this dry air after it has been placed in the damp what will be the effect? The air will press with greater force on the surface of the mercury. Yes.

And what will be the effect of this on the column in the tube? It will rise. Yes. And the drier the air the greater will be the pressure and the higher will the column stand.

If, therefore, the mercury is observed to rise, even when it is still raining, what may be expected? Fairer weather. Yes.

(4) *Conclusions.*—Thus the children will learn that the rising or falling of the column of mercury in the barometer indicates the *amount of pressure of the air;* and as damp air is lighter than dry

the pressure must be less, and *a falling barometer indicates coming rain*, while dry air being heavier than damp *a rising barometer indicates fine weather.*

Impress upon the children the fact that the great use of the barometer is to indicate the approaching changes of weather. Tell the children respecting the coincidence between the height of the barometer and the state of the weather, that the following indications have been marked on the scale, counting by thirds of an inch above and below 30 inches:—

Height.		*States.*
31 in.	=	Very dry.
$30\frac{2}{3}$ in.	=	Settled weather.
$30\frac{1}{3}$ in.	=	Fine.
30 in.	=	Variable.
$29\frac{2}{3}$ in.	=	Rain and wind.
$29\frac{1}{3}$ in.	=	Much rain.
29 in.	=	Storm.

(5) *What has been observed respecting the Rise and Fall of the Barometer?*—Tell the children that among the many things which have been observed respecting the variations of the barometer the following may be considered as established:

a. The lowest depressions occur when the wind is blowing from the south or south-east, and then there is much rain and wind—gales may be expected.

b. If the mercury keep falling when the wind is from the south, much rain may be expected.

c. A falling barometer with the wind at the north brings the worst weather: in summer rain and storm. This is rare in England.

d. When the mercury falls to a very low point in the summer, storms of wind and rain with thunder may be expected, and cold unseasonable weather afterwards.

e. If mercury fall during a high wind from points between south and west, an increasing storm is probable. If the fall be rapid the wind will be violent, but of short duration; if the fall be slow, the wind will be less violent, but of longer duration.

f. If the depression of the mercury be sudden and considerable, with a westerly wind, a storm may be expected from the north-west or north, during which the mercury will rise to its former height.

g. A rising barometer with southerly wind is usually followed by fine weather.

h. When much rain falls with a steady rising barometer, and the mercury is very high, a long period of fine weather will succeed.

i. No great storm ever sets in with a steady rising barometer.

j. North and south winds are the origin of all our most violent storms.

2. *To determine the Height of a given Place above the Level of the Sea:*

(1) Refer to the lessons on the ATMOSPHERE, especially to the two physical properties, Compressibility and Elasticity, and then proceed thus:

Where, then, is the air densest? At the level of the sea.

When the air is dry and calm the column of mercury in the tube stands at about 30 inches. If the air is elastic, what will be its state at any considerable distance above the sea level? Thinner or rarer, because there is less pressure from above.

(2) If a barometer be placed in such a position, there will be less pressure exerted on the surface of the mercury in the cistern. How will this affect the column in the tube? It will not stand as high as it did at the sea level.

Suppose the barometer to be carried to a still greater height, there will then be still less pressure on the surface of mercury. What will be the effect on the column in the tube? It will stand at a lower level than it did before.

(3) The same kind of change in the column will occur for every alteration of height above the level of the sea at which the barometer is placed.

In order to determine the exact height of the spot on which the barometer stands, what must be known?

(4) The exact amount of the fall in the column for a definite height above the sea level. This has been ascertained, and found to be $\frac{1}{10}$th of an inch for every 100 feet.

If, therefore, on ascending a mountain, the barometer is found to stand at 29 inches, while at the same time one at the sea level is standing at 30 inches, we should know that the spot was exactly 1000 feet above the level of the sea. If the column of mercury stood at 28½ inches, then the place would be 1500 feet above the sea level, and so on.

This leads to a very simple rule for determining the height of any place, namely, add $\frac{1}{10}$th of an inch to the height of the column of mercury up to 30 inches, and for every tenth so added reckon 100 feet.

Lesson 144.—THE COMMON PUMP.

Provide model or diagram of the common suction-pump. See that the children know its use, namely, to lift water from a lower to a higher level; hence called *lift-pump.*

Some pumps are used for *forcing* water to a great height; these called *forcing-pumps.* The present lesson will be on the *Common Lift-pump.*

I. Parts.—Children to observe the diagram or model, and learn to distinguish the parts, namely:

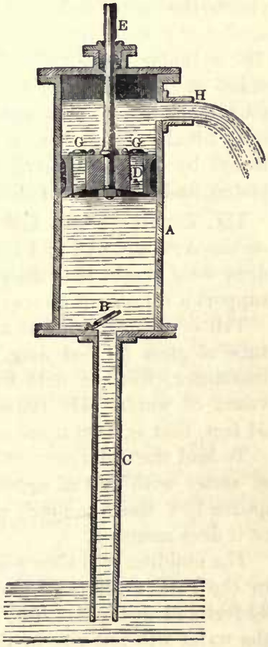
1. The barrel or cylinder, A. In the model, made of glass; in the actual pump, of metal or wood.

2. At the bottom of the cylinder a valve opening upwards, B. The valve is a metal disc fixed to a hinge on the edge of the orifice to be closed. In order more effectually to close it, the lowest part of the disc is covered with thick leather.

3. A pipe which dips into the reservoir from which the water is to be raised. This pipe is called the suction-pipe, C.

4. A piston D, which is moved up and down the cylinder by a rod E (piston-rod), worked by a handle. The piston is perforated on either side of the rod; the upper apertures are closed by a valve G, opening upwards. An empty cotton reel will serve to illustrate the construction of the piston. Instead of sewing-cotton wound round, suppose tow to be used.

5. At the top part of the cylinder there is a spout H, for the escape of the water.



Section of a Suction-pump.

II. Action of the Pump.—If a model is provided, use it, and let the children describe the action of the parts, and the effects. If a diagram, then describe it.

When the piston D, by the handle being pulled down, rises from the bottom of the cylinder A, a vacuum is produced below, and the valves G G are kept closed by the pressure of the air in the upper part of the cylinder; while the air in the suction-pipe, in consequence of its elasticity, raises the valve B, and partially passes into the cylinder. The air being thus rarefied, water rises in the suction-pipe C until the pressure of the water, together with the pressure of the remaining air, counterbalances the pressure of the atmosphere on the water in the reservoir. When the piston descends, by the handle being pushed up, the valves G G close by their own weight, and prevent the return of the air from the cylinder into the suction-pipe. The air compressed by the piston opens the valves G G on their upper sides, and escapes by the spout. With the second stroke of the piston the same series of effects are produced, and after a few strokes the water from the reservoir reaches the cylinder and fills it. The cylinder being full, the next descent of the piston closes the valve at the bottom of the cylinder, and opens that on the upper part of the piston. The water thus passes above the piston by which it is lifted. There is now no more air in the pump, and the water forced by the atmospheric pressure rises with every stroke of the piston, and flows out of the cylinder through the spout.

III. Limit of the Lifting Power.—Refer back to the lessons on the ATMOSPHERE and the BAROMETER. In these lessons the children were taught that the pressure of the atmosphere is sufficient to support a column of mercury 30 inches high at the level of the sea.

Tell of the experiment of Pascal at Rouen in 1646. He took a tube of glass 50 feet long, closed at one end like the stem of the barometer; filled it with water, and then placed it vertically in a vessel of water. He found that the water stood in the tube at 34 feet, that is, 13·6 times as high as mercury in the barometer.

To lead the children to see why this is the case, compare the weight of water with that of mercury, that is, 13·6 as light; and so it requires 13·6 times as much water to equalize the pressure of the air as it does mercury.

The children will thus see that if a perfect vacuum was produced in the suction-pipe and barrel of the pump, the water would rise 34 feet and no higher. But as the vacuum made is not a perfect one, the water will not rise to the height of 34 feet in the suction-pipe. In actual practice the height does not exceed 26 to 28 feet, so that if the water to be raised is at a lower depth than this the suction-pipe must be made in lengths, and a valve placed at the top end of each length. The water will then be lifted from one to the other by the upper action of the piston, and held in each as a separate pump by the downward action of the piston. In this case it takes longer at first to raise the water to the surface of the earth; but when once the cylinder is full the action is as rapid as in the case of a less depth.

LESSON 145.—HEAT.

I. Introduction.—*Heat and cold are relative terms.* Put a piece of iron or any other metal in fire or flame of spirit-lamp. When sufficiently heated hold it close to a boy's hand. What can he say of the substance? It is hot. Plunge the iron into cold water. Let the boy touch the bar; what can he say of it now? It has less heat, it is only warm. If some ice is at hand place the bar in it, and then let the boy feel it. What can be said of its temperature now? It has less heat still; it is cold. The children will thus see that while there is such a thing as heat, cold is simply the loss or absence of heat.

II. Sources of Heat:

THE SUN. Children name the two things which the sun gives. Light and heat. But the amount of heat variable according to season of year and the time of day, and never intense enough for some of the purposes for which man needs it, so he has to produce it by one or other of the following means:

1. *By Combustion.*—Light a candle, a boy to place his hand at some distance above the flame; tell the class what he observes. Heat is given off by the flame. Refer to fires in grates. Burning wood and coal give off heat. When doing so are said to be *in a state of combustion.*

2. *By Friction.*—Take a common brass button with flat top. Place it on boy's hand. It feels cold. Rub it on a piece of roughish wood and then place it on the back of his hand. What difference? It is warm. Whence the heat? Caused by friction. Rub the button very briskly and with greater pressure. It has more heat. Rub longer and with greater pressure. What effect? More heat. Hence the conclusion, the greater the pressure and the more rapid the motion, the greater the heat.

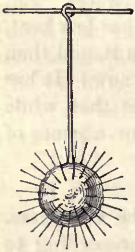
An example of the production of heat by friction is seen in the axles of carriage wheels. By rubbing against the boxes they often become so strongly heated as to cause the wood to take fire.

Tell that smooth surfaces cause less friction than rough ones, and smooth ones well oiled less than those not oiled. Hence the practice of putting oil or other kind of grease into the boxes of wheels and on the bearings of machines to prevent the friction.

3. *By Percussion.*—Take a piece of lead, or any other metal; place it on a boy's cheek. What its temperature? It is cold. Strike the metal sharply on a stone several times with a hammer. Child now feel it. It is warm. Whence the heat? By striking, or by *percussion* as it is called.

III. How Heated Bodies lose their Heat:

1. *By Radiation from their Surfaces.*—Make a piece of iron red hot; suspend it by hook and string to the gasalier. Call attention to what takes place. Iron gradually loses its redness. Gets cooler. How? Heat passes off from all parts. Tell that if heat were visible it would be seen to pass from the surface of the iron in straight lines, as in diagram; these lines are called *rays*, and the heat thus given off is said to be *radiated.* Radiation is entirely from the surface.



(1) *The amount of Radiation not the same under all circumstances.*—Just before commencing the lesson fill two vessels of the same size with boiling water, one blackened and the other bright. Tell what you have done. Let a boy place his hand first on the black vessel then on the bright, and say what he observes as to the temperature of each. The blackened vessel is the cooler of the two. What, then, can they say of the water in the vessels? That in the blackened vessel has lost more of its heat than that in the bright vessel. What conclusion, then, can they draw? That the radiation is greater from the black surface than from the bright one.

Tell that the radiation is the greatest from surfaces covered with lampblack, and least from white and polished surfaces, as of bright tin, the latter being as 12 to 100.

Show the use of this knowledge in everyday life. Liquids placed in metal vessels with polished surfaces will, when removed from the fire, retain their heat for a longer period than when put in blackened vessels. Light-coloured garments worn next the skin prevent the blood from losing its heat.

(2) *Radiated Heat may be Absorbed or Reflected.*—Place a cool body in front of a heated one. After a while let a child touch it. It is warm. Whence its heat? Has received it from the other. The rays which have passed from the one have passed into the other, or have been *absorbed.*

Place both the blackened and polished vessels in front of the fire.

After a while let a child touch both, and say what he has found out as to their temperature. The black is the warmer. But both vessels are at the same distance from the source of heat, therefore the same amount has fallen on each. Why have not both the same temperature? One has received more than the other. But if the polished vessel did not receive the rays, what did it do to them? Sent them back, or, as it is said, *reflected* them.

Thus, then, they learn that black surfaces absorb radiated heat, and polished and white surfaces reflect it. They must bear in mind that bodies which are good radiators of heat are good absorbers, and *vice versa*.

Show the use of this knowledge in everyday life:

a. Cold bodies placed in front of the fire in black vessels will get warmer sooner than if placed in polished vessels.

b. If exposed to source of heat white garments will throw back the rays and so keep the wearer cool, and whitewashed slates will keep a room cool in the summer.

2. *By Conduction.*—Get a flat piece of iron; make it hot; place on the upper surface a thin piece of copper and a piece of bone or wood. Let a boy touch the copper with one finger and the bone with another. Say what he perceives. The copper is hot, the bone is not. From whence has the copper obtained its heat? From the heated iron. How? The heat has passed through it. But as the bone has been in contact with the same piece of iron, why is it not hot? The heat from the iron has not been able to pass through the bone.

Tell that because the copper has allowed the heat to pass through its substance it is said to be a *conductor* of heat, and the heat from the iron has passed into the copper by *conduction*. But the bone does not allow the heat to pass along its substance. It does not conduct the heat. Tell that what is true of the copper and bone in this respect is true of many other substances, and hence there are *conductors* and *non-conductors* of heat.

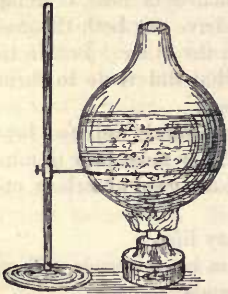
All conductors, however, have not the same amount of the power. Among the metals silver is the best, and iron one of the worst. Cotton, wool, straw, and bran are all non-conductors.

Show the importance of this knowledge in everyday life:

(1) Copper kettles placed on hot plates of stove will conduct heat to surface of water more readily than iron kettles.

(2) If a heated body is to be kept hot, and yet cannot be placed near source of heat, it should be covered with a non-conductor. Hence use of cosey for tea-pot.

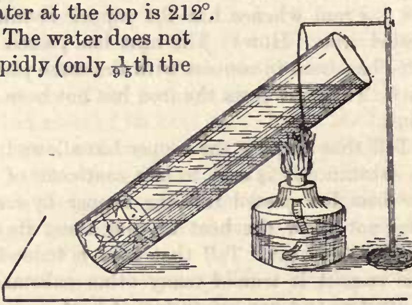
3. *By being carried, or by Convection.*—Provide a clean Florence-oil flask, half fill it with water, and place it over a spirit-lamp. Call attention to what takes place. Bubbles rise from bottom to top. Sprinkle a small portion of sawdust in the water. These rise and fall. Explain action. Particles of water are heated, and so become lighter than those not heated, and so rise: the colder particles are heavier, and so fall. Each particle of water as it receives heat carries it upwards, and thus at last the whole body of water is made hot. This carrying of the heat is called *convection.* Water is a good carrier of heat.



To illustrate the Convection of Heat by Water.

Put some ice in a test-tube, cover it with a few pieces of coal so as to keep it at the bottom, and nearly fill the tube with cold water. Hold the tube in a slanting position, and apply flame of spirit-lamp to the upper end. Call attention to what takes place. After a while the water at the top will simmer, then boil, while the ice at the bottom will remain. A thermometer inserted will show that the water at the bottom of the tube is 32°, while water at the top is 212°.

Explain why this is. The water does not *conduct* the heat very rapidly (only $\frac{1}{95}$th the power of copper), and as the heated particles are lighter than the cold they cannot convey them downwards, and so we see the curious sight of boiling water standing on a layer of icy cold water.



To illustrate that Heat is not Convected downward.

Show the use of this knowledge in everyday life. If we wish to heat water in the least possible time apply the heat to the bottom of the vessel and not to the sides only. Water may boil in the spout of a kettle and yet that at the bottom be only warm.

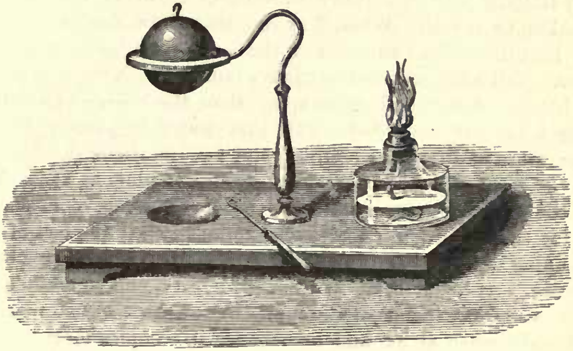
IV. Effects of Heat:

1. *It expands Bodies.*

A. Solids.—Procure a small ball of copper which exactly fits into a ring, as in the diagram.

Call attention to the fact that the ball will just pass through the ring when cold. Heat the ball. It will not now pass through. It is too large. It has expanded by heat. Tell that what is true of copper in this respect is true of all solids—all expand by heat, though not all in the same degree.

Having cooled the ball of copper, call attention to the fact that it again passes through the ring. Hence it has contracted by the loss of its heat.



To illustrate the Expansion of Solids by Heat.

Show the importance of this knowledge in everyday life. Tell that when a substance either expands or contracts it exerts a force, and this must be provided for. Hence:

(1) The bars of furnaces must not be fitted tightly at both ends: one must be free, otherwise, in expanding, they would split the masonry.

(2) In making railways a small space is left between the rails: if they touched the force of expansion would cause them to curve or would break the chairs on which they rest. The length of the line of rail between London and Manchester is greater by 500 feet in summer than in winter, but this is provided for by the rails not touching.

(3) If a glass is heated or cooled too rapidly it cracks: this arises from the fact that glass being a bad conductor of heat the sides become unequally heated, and consequently unequally expanded, which causes a fracture. The *contractile* force is also turned to good account:

(1) In securing the tires on wheels. The tire being made red hot, and thus considerably expanded, is placed on the circumference of

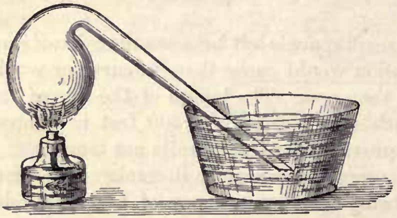
the wheel and then cooled. The tire, when cold, embraces the wheel with such force as not only to secure itself on the rim but also to press home all parts of the wheel.

(2) The plates of boilers are securely held together by means of rivets, which, being made to fit when red hot, and fastened, draw the plates together with great force when they cool.

(3) Bulging walls are drawn upright by means of rods which are heated and screwed. When they cool they draw the walls together.

B. LIQUIDS.—Some time before the lesson fill a bottle with boiling water. Tell what was done. Now examine it. Not quite full. So the hot water occupied more space than the cold. The water in being made hot expanded. Tell that water in passing from the temperature of 40° to the boiling point 212° increases $\frac{1}{30}$ of its bulk. Thus 30 pints of water at 40° will measure 31 pints at 212°. Hence if kettle filled up to brim will run over when boiling, room should be left for the expansion. Endeavour to make clear the fact of water expanding with cold as it passes from 40° to a lower degree of temperature. At 40° it is at its greatest density, and so occupies least space; at 39° it expands and occupies more space; at 38° more; and so on until when at 32° and become ice it occupies most space (see lesson on ICE). Hence ice lighter than water and of course floats. If the water is confined in closed vessels the expansion on assuming the solid state will burst the vessel. It is this which causes the water-pipes to burst in the winter. To prevent the mischief thus caused all pipes which are exposed to the air should be covered with straw or some other non-conducting substance.

C. AIR.—Place neck of empty flask under water; apply spirit-lamp to the bulb; call attention to what takes place. Bubbles of air pass out of the flask and rise through the water. Why is this? The air in the flask made warm occupies more space—has expanded.



To illustrate the Expansion of Air by Heat.

Cool the flask. What now takes place? The air left occupies less space, and the water rises in the neck of the flask to take its place.

Show the use of the knowledge of this fact. Warm air is lighter than cold. So when the air in a room is made hot by gas, it will rise to the ceiling. If means provided for its escape it will pass out, and if means provided cold air will enter to take its place. This is the principle of *ventilation*.

2. *It converts Solids into Liquids and Vapours.*—Place bees'-wax near the fire; call attention to what takes place. Wax first softens, then melts—becomes a fluid. Do the same with sealing-wax, butter, &c.,—all these solids are converted into fluids. Refer to lesson on FUSIBILITY.

Call attention to the operation of boiling water. Water passes off in vapour. Place a piece of camphor in test-tube and apply heat. The solid passes off in vapour. Thus, then, they see that heat will convert solids into fluids, and both solids and fluids into vapours.

3. *It hardens some Solids.*—Show some wet clay. Soft, plastic. Show a piece which has been baked. Hard and brittle. How the change effected. By being baked. So heat here has *hardened* the material.

V. The Idea of Latent Heat.—Into a flask place a small quantity of pounded ice. Insert thermometer, and call attention to the temperature, 32°. Apply heat. Ice begins to melt, so heat has been communicated. Continue to apply heat. But temperature does not rise until the whole of the ice is melted. Heat passed into the water, but did not show itself; it was hid up, as it were, in the water.

Continue to heat the water, temperature continues to rise. When the water boils call attention to the exact temperature, 212°. Continue to apply heat. Still the thermometer remains at 212°. Heat has been taken in by the water, but does not make any sensible difference to the temperature. The heat is hidden.

Tell that the heat thus hidden up, as it were, in the water, is called *latent*. In the case of the water in which the ice was melted, the latent heat of water; in the case of the boiling water, the latent heat of steam.

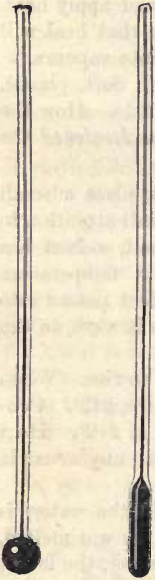
Show the application of this. As the temperature of 212° is that which suffices to cook our food—albumen coagulates at 180°—the amount of heat which is sufficient to keep the water at that temperature is all that is needed; all the rest is so much waste of force. On the other hand, if the object is to make steam, then the more heat that is applied the better. Again, in time of frost all the ice should be taken out of the water before it is placed over the fire, otherwise the heat which is applied will be used merely to melt the ice, without raising the temperature of the water, and this will be a loss of force.

LESSON 146.—MEANS OF MEASURING THE CHANGES OF TEMPERATURE IN BODIES.

THE THERMOMETER.

I. Parts.—Children to observe an ordinary mercurial thermometer, and point out its parts. As pointed out to be named by the teacher, thus teaching that: A thermometer consists of a *glass tube* with a very *fine bore;* at the end of the tube is blown the *bulb,* a cylindrical or spherical reservoir, Figs. 1 and 2. Both the bulb and a part of the *stem* are filled with mercury, and the expansion is measured by a *scale,* graduated on a *frame* to which it is attached, Fig. 3, which is a diagram of a registering thermometer. In the upper part of the bore a piece of steel wire is placed. When the mercury expands it pushes this forward; as the mercury contracts, the indicator, as it is called, is left, and so shows the highest point reached: hence its name. When the minimum degree of heat is recorded the indicator is immersed in pure spirits of wine; as the fluid contracts by cold, the indicator is carried down, and left as the fluid again expands.

Fig. 1. Fig. 2.



Mercurial Thermometers.

II. The Scale.—Prepare a diagram of the thermometer, so that the scale may be read by the children. They will thus see that the scale consists of a number of figures, say 0 to 220 upwards, and below 0, 1 to 20. The spaces between these figures are divided into tenths. Against certain of the figures and tenths there are words, thus, at 0, "zero;" at 32° above 0, "freezing;" at 212° above 0, "water boils," &c.

This is to signify that at the lower of these temperatures water always becomes solid or turns into ice, and at the higher of the two water always boils when the pressure of the atmosphere is the same

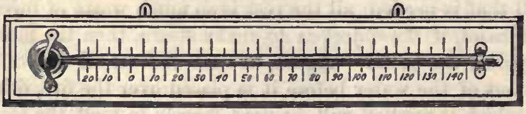
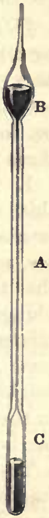


Fig. 3.—Phillip's Maximum Thermometer.

as at the level of the sea. These two points are considered fixed, and between these there are other temperatures indicated, as at 98° above 0, "blood heat."

This particular scale, which is the one used in England for ordinary purposes, is called *Fahrenheit*, from the name of its inventor.

Fig. 4.



III. Filling the Thermometer.—The children will naturally think that the filling of the thermometer might be effected by pouring the mercury down the tube when the top end is open. Tell them that this cannot be done, on account of the fineness of the bore, and so another way has had to be devised. Make diagram, and explain:

1. When the stem A with the bulb has been formed, a small funnel B is blown on at the top, and is filled with mercury; the tube is then slightly inclined, and the air in the bulb expanded by heating it with a spirit-lamp, or as in Fig. 5.

2. The expanded air partially escapes by the funnel, and on cooling the air which remains contracts, and a portion of the mercury passes into the bulb C.

3. The bulb is again warmed and allowed to cool, a fresh quantity of mercury enters, and so on, until the bulb and part of the stem are full of mercury.

4. The mercury is then heated to boiling; the mercurial vapours in escaping carry with them the air and moisture which remain in the tube.

5. The tube being now full of the expanded mercury and of mercurial vapour, is sealed up by melting the glass. When the thermometer is cold the mercury will be found to fill the bulb and a portion of the stem, as in Figs. 1 and 2.

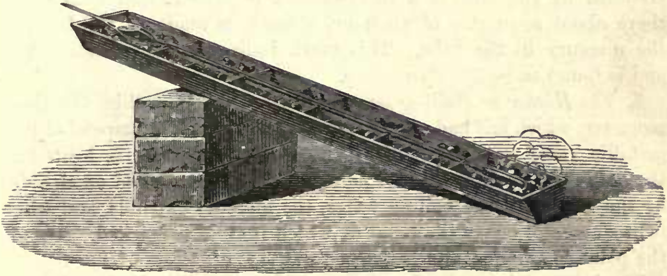


Fig. 5.—Furnace for Heating Thermometers.

(Fig. 6 illustrates another mode of introducing the mercury. The air in the bulb and funnel is expanded by heat, the open end of funnel is then inserted into the quicksilver, and as the air contracts again the mercury rises to take its place. The operation is repeated until the tube is full.)

IV. Graduation of the Thermometer, or making the Scale.—By referring back to the scale the children will see that the two fixed points must be found and marked. Tell how these points are found:

1. *The Lower or Zero.*—To find this, equal weights of sal-ammoniac and snow or pounded ice are mixed. The bulb of the thermometer is plunged into this mixture and left for some time, and the height of the mercury in the tube carefully marked.

To obtain the exact freezing-point, snow or pounded ice is placed in a vessel, in the bottom of which is an aperture by which water may escape. Into this vessel filled with the pounded ice the bulb of a thermometer is placed; and after being there about a quarter of an hour, a mark is made at the level of the mercury in the tube. This mark indicates the freezing-point, and is found to be 32° above zero.

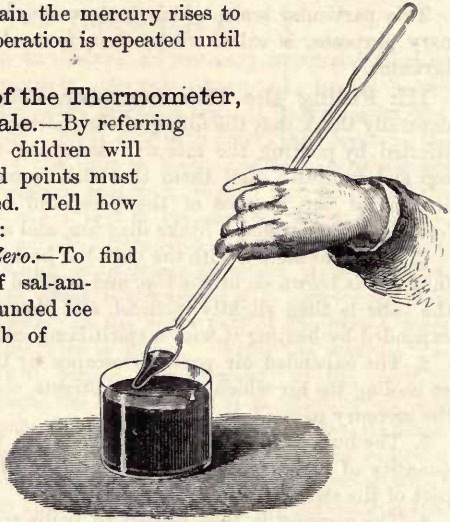


Fig. 6.—Introduction of the Mercury.

2. *The Higher or Boiling-point of Water.*—To find this, the thermometer, which has had the zero point marked off, is suspended in a metallic vessel containing distilled water. The water is heated to the boiling-point, and the thermometer being surrounded on all sides by the vapour of the boiling water, the mercury expands, and when it becomes stationary the point at which it stops is marked. This is the point sought for, and is marked 212°.

The interval between the higher and lower points is then divided into equal portions of ten each, and the scale is complete.

LESSON 147.—WEIGHT AND SPECIFIC GRAVITY.

I. Weight:

1. *Idea.*—Provide three or four bags of equal size; fill them respectively with feathers, saw-dust, sand, and small leaden shot. Call out a child, and place the bags, one by one, on the palm of the hand, commencing with the feathers and ending with the shot. The child to say what each does to his hand. Pressed it. Which way? Downwards. Whether each pressed in the same proportion? No. Which the least? The feathers. Which the most? The shot. What did each do? Pressed the hand downward. And if the hand had been removed what would have happened to the bags? They would have fallen to the ground.

2. *Name.*—Tell the children that *this pressure on the hand was caused by the weight of the bodies.*

Do the same with other substances. All press the hand downwards; all seek to fall to the earth; all have *weight.*

II. Mass:

1. *Idea.*—Empty the bags which have been used, and fill each with feathers, taking care that they each contain the same quantity (by weight). Pack the contents of two into one. The one bag now weighs as much as the two did, and as much as the two separate ones do still. Compare the *bulk* of two with the one—twice; compare the *weight* of the one with the two—equal. Thus children will see that the smaller bulk has the greater weight. There is as great a quantity of matter in the one bag as there is in the other two, and twice the quantity in the one as in one of the others.

2. *Name.*—Tell the children that the quantity of matter which is in a given body is called its *mass,* and we can say that the mass or weight of a body equals the quantity of matter in that body.

Provide some lumps of wood, stone, and metal, all the same size. Children will notice that they are all equal in bulk. Have them weighed. The stone is heavier than the wood, and the metal heavier than the stone. Bulk for bulk, they are equal; weight or mass for mass, they are different.

III. Specific Gravity:

1. *Idea.*—Provide cubes of several kinds of matter,—say wood, coal, and lead. Take one cube of wood and weigh it against another cube of the same kind of wood; do the same with the coal and the lead. Next weigh a cube of wood against one of coal, then of lead —children saying what they have observed, namely:

(1) The cubes of the same material are of equal weight or density.

(2) The weight or density of each kind of material is different. The wood has a weight of its own, the coal a weight of its own, and the lead a weight of its own. The same would be the case if any other mineral or vegetable substance had been chosen.

2. *Name.*—Tell the children that the particular weight which a particular body has—this weight of its own—is called its *specific gravity.*

3. *How to find the exact Specific Gravity of a Body.*—If possible provide a cube of lead, say a one-inch cube, and a vessel into which it will exactly fit. Stand a glass tumbler in a saucer, and fill it with water just up to the brim. Now carefully lower the cube of lead into the water, children observing and saying what takes place:

(1) The lead sinks, showing that it is heavier than the water.

(2) As the lead is lowered into the water, some of it runs over into the saucer, and still the glass is full. Why? (See lesson on IMPENETRABILITY.)

Now remove the glass, and carefully pour the water out of the saucer into the empty cube. What do they observe? The water which has been displaced by the lead is exactly the same in bulk as the lead.

Now take the cube out of the water, wipe it dry, and weigh it. Notice the exact weight. If possible weigh it again in the water, when it will be found to have lost a portion of its weight, about $\frac{1}{11}$.

Next weigh the water which has been displaced by the lead; it is exactly equal to what the lead lost by being weighed in the water.

Tell the children that this fact enables us to ascertain how much heavier the lead is than the water. For *if the weight of the lead in the air is divided by the difference of that weight and the weight in the water, we ascertain how many times heavier it is, and that is called its* SPECIFIC GRAVITY. Or, to put it in another form. Divide the real weight of the body by the weight it *loses* in water: the quotient will be the specific weight.

The children will thus see that in considering specific gravity we have to compare *bulk with bulk*, and *take a standard.* Tell them that in this country the standard of comparison is pure water, that is, distilled water, a cubic foot of which weighs within a small fraction of 1000 ozs.; and by the method which they have just worked out the relative weights of solids have been ascertained, and these are spoken of as their *specific gravities.*

TABLE OF THE SPECIFIC GRAVITY OF VARIOUS SUBSTANCES.

Metals.		*Rocks.*		*Vegetable Substances.*		*Liquids.*	
						Mercury,.....	15·596
Platinum,	22·06	Diamond,...	3·53	Boxwood,..	1·32	Sulphuric acid,	1·841
Gold,.....	19·26	Marble,.....	2·84	Oak—heart,	1·17	Water,........	1·000
Lead, ...	11·35	Granite, ...	2·75	Ebony,.....	1·13	Sea-water,....	1·026
Silver,....	10·47	Sandstone,..	2·60	Beech,......	0·75	Milk,.........	1·030
Copper,...	8·85	Quartz, ...	2·65	Willow, ...	0·49	Olive oil,.....	0·915
Iron,.....	7·79	Glass, ...	2·50	Poplar,.....	0·36	Turpentine...	0·865
Tin,......	7·29	Porcelain,...	2·24	Cork, ...	0·24	Alcohol,......	0·792
Aluminium,	2·67	Sulphur,....	2·08	Elder-pith,	0·08	Ether,........	0·736

SECTION IV.—THE ELEMENTS OF MECHANICS.

LESSON 148.—THE LEVER.

I. Introduction.—Let a boy try to overcome the resistance offered to his muscular force by a heavy weight—say 1 cwt. He cannot; so he asks another boy to help him: together they can move the weight. But the resistance offered by a mass might be so great that the force of all the boys in the class would not be able to overcome it, as would be the case with a piece of stone the size of the school table.

As, however, the resistance offered by the mass of bodies must be overcome in order that builders, engineers, and other workmen may carry on their work, mechanical means have been invented to enable them to move great weights. Let the children mention any contrivance which they may have seen in use, as the crowbar, the wheel-barrow, &c.

Tell the class that all the contrivances can be grouped under one or other of six simple machines, namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw. These are called the *Mechanical Powers.* Three of these are considered *primary,* namely, the lever, the pulley, and the inclined plane; and three *secondary* as derived from the others, namely, the wheel and axle, derived from the pulley, the wedge and the screw, both derived from the inclined plane.

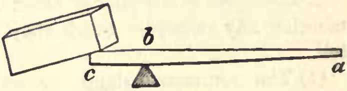


Fig. 1.—Lever.

II. Action of the Lever.—Make a diagram, as in Fig. 1. Children to point out the parts. *a c,* A rigid bar of iron; *b,* a fixed point on which the bar can move. This point called the *fulcrum*. The oblong block represents the load to be moved.

By examination of Fig. 2 children will see the action. The fulcrum *b* divides the lever *a c* into two parts, called the *arms*. At one end of bar is load to be moved, or the *weight* W; at the other end the *power* P, which is to move the weight.

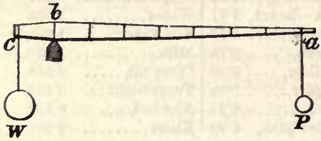


Fig. 2.—Lever of the first kind.

Call attention to the exact position of the fulcrum in this case, namely, between the moving power and the resistance or weight to be moved. Such a lever is called *one of the first kind*.

III. Use of the Lever:

1. Next lead the children to see how the lever is used:

(1) One end of the bar is inserted between the earth and the stone—the weight.

(2) The fulcrum is placed at a little distance from the weight.

(3) Force is applied at the end of the bar so as to pull the lever downward.

(4) As the lever is moved downwards the weight is moved upwards.

If possible have a weight to be moved, and by altering the position of the fulcrum in respect to the power and the weight, lead the children to see that *the advantage of this kind of lever depends upon the length of the arm between the fulcrum and the power*. In proportion as that arm is lengthened or shortened will be the gain or loss of power, and this in a way they will learn when they study mechanics. This much perhaps may here be taught. If the fulcrum be so placed that it divides the bar into two equal arms, then the power and the weight must be equal to produce equilibrium, as in the balance or scale. If the fulcrum be so placed that the arm on the power side be double that on the weight side, then the power need be but one-half the weight.

2. *Examples of this kind of Lever in everyday use.*—Let the children mention any examples which they may have seen. If not known, tell.

(1) The common balance or scale (see lesson on A PAIR OF SCALES) and the child's see-saw.

(2) The poker used for stirring the fire. The bars of the grate the fulcrum, the coals to be raised the weight, and the hand applied at the end of the poker the power.

(3) The spade when used in digging.

(4) Scissors when used in cutting are double levers of this kind.

3. Next make a diagram of a lever of the *second kind*, and children point out the parts, noticing particularly the position of each, and comparing with the first kind.

Here the power and weight are on the same side of the fulcrum, and the weight is between the power and the fulcrum, and the long arm of the bar has to be pulled up (Fig. 3).

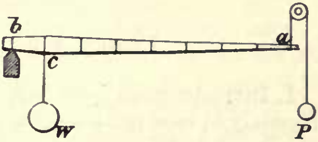


Fig. 3.—Lever of the second kind.

4. *Examples of this kind of Lever.*—Show picture of wheel-barrow in use, when the children will see that it is an example of a lever of this kind, the wheels being the fulcrum, the contents of the barrow the weight, and the man wheeling it the power.

A chopping knife is also an example of this kind of lever. The knife fixed at one end is the fulcrum, the bread to be cut, and which is put under the knife, is the weight or load, and the power is the hand of the person cutting. Nut-crackers are double levers of this kind.

5. Now make a diagram of a lever of the *third kind*, and the children point out the parts, noticing the position of each, and comparing with the first and second kind.

Here the power and the weight act on the same side of the fulcrum, and the power is between the fulcrum and the weight. The power is applied to lift up the lever, and so raise the weight (Fig. 4).

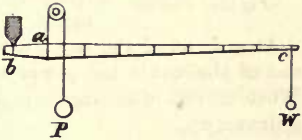


Fig. 4.—Lever of the third kind.

6. *Examples of this kind of Lever.*—Let the children mention any examples of this kind of lever which they may have seen. Supply what not given.

(1) A fishing-rod. The fish to be raised is the weight. The rod itself is the bar. The hand at the end of the rod is the fulcrum. The other hand of the person placed at some distance from the fulcrum is the power.

(2) Whips and umbrellas are also examples.

(3) The structure of the human arm is another example. The fulcrum is the socket of the elbow-joint. The power is the strong muscle which passes down the front of the humerus and is attached

to the radius. The weight is the forearm, together with anything held in the hand.

(4) A pair of tongs is an example of a double lever of this kind.

LESSON 149.—THE PULLEY.

I. Introduction.—By reference to the fact that it is often necessary to raise great weights from a lower to a higher level, as in the case of building operations, lead the children to see that in such cases the lever could not be applied. Hence the necessity for some other contrivance. This found in the *pulley*.

II. Structure.—If possible procure a pulley; if not make a diagram of one, and let the class observe and describe it, namely:

1. A wheel with a groove cut all round its circumference, and movable on an axis. This wheel is called a *sheave*, A, Fig. 1.

2. A piece of wood (called a *block* B) in which the wheel is placed, and to the sides of which the axles of the wheel are fixed for support.

3. A cord which passes over the circumference of the sheave. This cord is called the *tackle*.

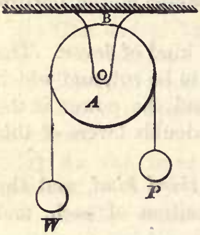


Fig. 1.—Pulley.

At one end of the tackle a weight to be raised, W. At the other end of the tackle the power to be applied to raise the weight, P. When the end of the rope is pulled the wheel revolves and the weight is drawn up.

III. Principle of its Action:

1. Place a cord over the wheel and make the ends level with each other. To one end fasten a weight, say 7 lbs. This will, of course, pull the cord down. Rearrange the cord and fasten another 7-lb. weight to the other end. Children will see that the one acts on the other through the whole length of the cord, and as both are equal the weights stand at equal distances, or are said to be *in equilibrium.*

2. Tell why this is the case. The cord is flexible, but not extensible, and the force which is brought to bear on one part is communicated to every other part, and thus the force which the 7 lbs. exert on one end is communicated to the other end, and so the weight W is held up by the weight P.

3. Notice here that as the power and the weight are equal no

mechanical advantage is gained: it requires 7 lbs. of force to overcome 7 lbs. of resistance. Though no advantage is gained it is a convenience, as by it we are able to apply power in the direction required.

4. Next show how the principle may be applied so as to result in a gain of power, as in the single movable pulley with parallel cords.

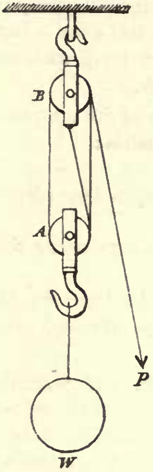


Fig. 2.—One movable Pulley.

Draw a diagram of a fixed and movable pulley with one flexible cord (Fig. 2). Suppose W to be the weight to be raised and to equal 2 lbs. and the weight of the movable pulley, which is small, and P the power. This is supported by the two parts of the cord lying between A and B, that is, each bears 1 lb. Now the power at P need only be equal to the resistance borne by each part of the whole rope, which is 1 lb. Therefore 1 lb. at P will balance twice that weight at W. If the resistance at W be equal to 4 lbs., then 2 lbs. at P would raise it; or if the weight at W be 8 lbs., then the power would need to be but 4 lbs., and so on. Children will thus see that this kind of pulley is a decided gain of force.

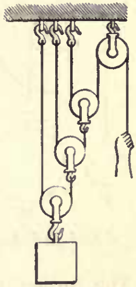


Fig. 3.—Three movable Pulleys.

5. Next lead the children to see how more power may be gained by dividing the rope into a greater number of portions and using a greater number of pulleys (Fig. 3).

The children will see that here the cord is divided into three portions, and these pass round the four pulleys, and as the tension in every part is that produced by the weight of P, the whole force applied to raise the load W is the weight P multiplied by the number of strings attached to the lower block, namely, 4. So if the power be 2, the force brought to bear on W will be $2 \times 4 = 8$. There being three movable pulleys, the one at the top is fixed; if, however, four movable pulleys are used, the power 2 would raise 16 W.

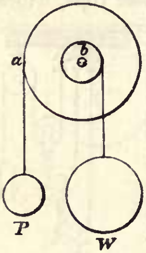
This system of block and tackle is the one in common use in building operations, in dockyards, and on board ship.

Lesson 150.—THE WHEEL AND AXLE.

I. Introduction.—From the examination of diagrams of levers in action the class will see that they can only be used to move weights over short distances. The stone can be raised on one side when the arm of the lever is pressed down, or turned over, it may be, when the arm of the lever is pushed up. But it is often necessary to raise a weight through a long distance, and without intermission, as in the case of a ship's anchor, hence the necessity for some other contrivance which should have the advantage of the lever without its disadvantage. This is found in the *wheel and axle.*

II. Parts of the Machine.—Draw a diagram of its simplest form, and let children point out its parts:

1. A horizontal axle, *b.*
2. A large wheel *a,* which turns upon two pivots in the framework.
3. A cord wrapped round the axle supporting the load W.
4. Another cord wrapped round the large wheel, but in a contrary way to that on the axle, and supporting the power P.



Wheel and Axle.

III. Principle of its Action.—If possible procure a model in which the radius of the wheel is 24 inches and the radius of the axle 3 inches. The former is eight times the latter. Place an 8-lb. weight at the end of the cord round the axle, and 1 lb. at the end of the cord round the wheel. Children will see that the power *1 equals the weight 8.* (If no model can be procured, make a diagram same size and explain.) So that the advantage gained is as 1 to 8, and hence 1 cwt. of power at the wheel will raise 8 cwts. of load at W.

IV. Different Applications of the Principle:

1. *The Common Windlass,* as used to raise water from wells.—Draw diagram, and point out the parts. Explain to class that the same principle applies here as in the other case. The power gained is equal to the number of times the handle is greater than the radius of the axle. If the radius of the handle be 16, and the radius of the axle be 2, the advantage gained will be 8. So if a power of 40 lbs. be applied at the handle, 320 lbs. of load will be raised at W.

2. *The Capstan,* as used on board ship.—Tell the children that sometimes it is convenient to have the axle placed vertically, and the power is applied by means of bars or levers inserted in holes. Make

a diagram. Such a machine is called a *capstan*, and is used on board ship to raise the anchor. Explain that in this case the cable coils round the axle in the form of an endless rope, which winds round the lower part of the axle. As the anchor is drawn up the cable so raised unwinds from the upper part of the axle. Children will observe that the axle is made conical. Explain that this is so in order that the men may shift the cable upwards when necessary.

Cranes are an application of the wheel and axle.

LESSON 151.—THE INCLINED PLANE.

I. Its Nature.—If there is a hill in the neighbourhood of the school give the height and the length of the slope, and state the fact that a boy could manage to get a load to the top which was too heavy for him to carry on his back. How would he proceed? Yes. If it were round he would roll it up, if flat either push or draw it.

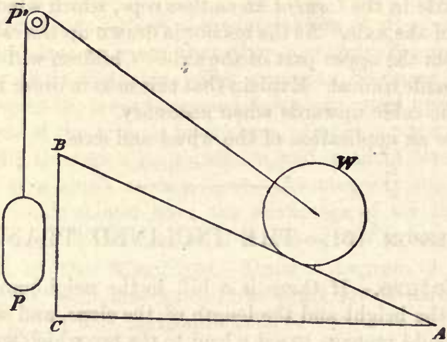
Make diagram of two hills—one with a short steep ascent, another with a greater vertical height, but with a longer and less steep ascent. Suppose a boy had to convey a load of equal weight up both, which do they think would be the easier task? Yes, the one with the long, gentle ascent.

II. Advantage.—Give the gain. This will be the number of times that the length of the slope, *or plane* as it is called, is greater than its vertical height.

Thus if the length of the plane be double its height, then the advantage will be as 1 to 2, that is, a load of 2 cwts. will only require a force of 1 cwt. to carry it up if the plane is smooth.

III. Use.—In consequence of this gain of power the inclined plane is much used to enable men to get casks and other heavy goods from the street into carts. When great masses of stone have to be put into carts then rollers are put under the stone. As the rollers are disengaged from the lower end of the stone they are put in under the upper, so that three or four rollers are kept beneath the stone as it is being rolled forward. The use of the rollers by decreasing the amount of friction adds to the power, and so is another advantage.

Sometimes the inclined plane is used in connection with a single pulley. Draw diagram, and explain: A C its horizontal base, C B its vertical height, and A C B the angle of elevation; W the weight to be raised, P the power to draw up the weight by means of a cord passing over the pulley P′. In this case additional power is gained. Supposing the base A C to equal 7 feet, and the distance between C B to be 2 feet, then the advantage gained will be as 7 ÷ 2 = 3½ to 1, so that a power of 1 cwt. will sustain a weight of 3½ cwts.

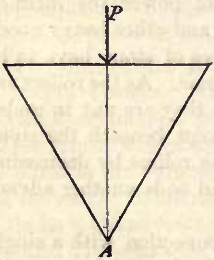


Inclined Plane.

The children will thus see the advantage of the inclined plane when used alone or in connection with other contrivances.

Lesson 152.—THE WEDGE.

I. Its Nature.—Question the children as to whether they have ever seen any one splitting a piece of timber by means of a sharpened piece of iron placed on the block and struck with a hammer or mallet. Tell them that such an instrument is called a *wedge*. Draw diagram of a single wedge, and compare it with the inclined plane, when the children will see that the wedge is really nothing more than a pair of inclined planes.



II. Common Use.—In the next place make diagram of the wedge as it is employed for splitting wood, both out and in use. Here the resistance acting at A arises from the cohesion of the material that is to be split. The power applied at P is the impetus given by the stroke of the mallet upon the head of the wedge.

Tell the children that there is a very simple rule by which the advantage gained may be calculated. It is as follows:—As the entire length of the wedge is to half the length of the back, so is the power to the resistance. Suppose, therefore, the entire length of the wedge to be 12 in., the length of the back to be 4 in., and the resistance caused by the cohesion of the wood to be equal to 150 lbs.; the amount of force required to split the wood can be ascertained by the rule of three, thus: 12 in. : 2 in. : : x lbs. : 150 lbs. In this case x lb. = 25 lbs., so a force of 25 lbs. applied to the head of the wedge will be sufficient to overcome the resistance, and so split the mass of wood.

LESSON 153.—THE SCREW.

I. Parts.—If possible procure a small screw press, or make a diagram, Fig. 1. Let children point out the parts: A, a strong iron frame fastened to the ground at B; C, the screw or thread which works in the grooves of a cylinder D; E, a lever to move the screw upwards or downwards; F, the material to be pressed.

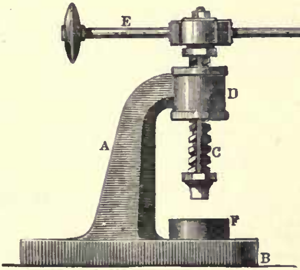


Fig. 1.

II. Principle of its Action. — Get a piece of very thick cardboard and cut it into a number of inclined planes of equal size, as Fig. 2. Wrap these on a cylinder, when the children will see that they really form a thread or screw like the one in the model (Fig. 3).

The children will thus see that the screw is really a movable inclined plane formed on the surface of a cylinder, and this being pushed further and further under a heavy body raises it up. Refer back to previous lesson on the INCLINED PLANE.

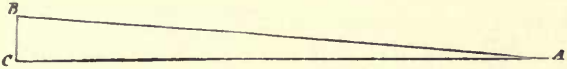


Fig. 2.

Tell the children that although they cannot now learn all about the exact power gained by the screw, there is one point which they can learn, and which they must try to remember: it is this—the advantage gained is equal to the circumference of the circle described by the power (E) ÷ by the distance between the threads of the screw (C).

Suppose, then, the lever (E) to sweep a circle of 20 feet, or 240 in., and the distance between the threads of the screw $\frac{3}{4}$ in., then the advantage of pressure gained will be $240 \div \frac{3}{4} = 320$; that is, if a man exert a pressure of 56 lbs. upon the extremity of the lever, then the downward pressure produced upon the material to be pressed $= 320 \times 56 = 17920$ lbs., or 8 tons.

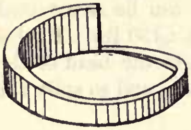


Fig. 3.

III. Application.—By examination of an augur, cork-screw, and gimlet, children will see that the screw can be used as an instrument of penetration.

THE END.

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